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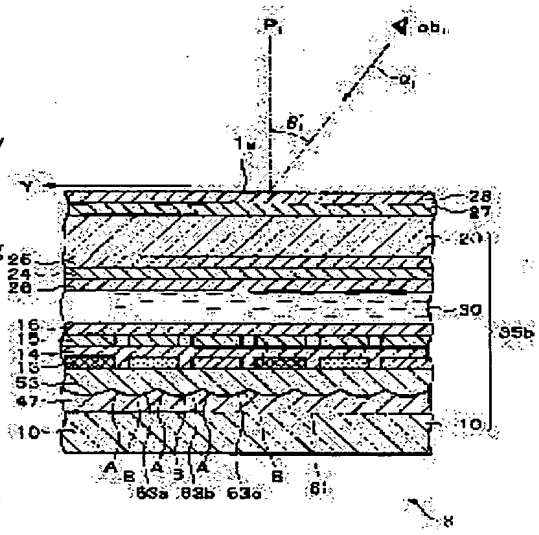
(54) LIQUID CRYSTAL DISPLAY DEVICE AND PORTABLE ELECTRONIC APPARATUS

(57)Abstract:

PROBLEM TO BE SOLVED: To provide the liquid crystal display device which has a viewing angle property that allows a display to appear brighter when a viewer looks at the display surface of the liquid crystal display device from a direction close to a normal line direction with respect to the display surface than when the viewer looks at the display surface from other viewing angles.

SOLUTION: An electrode and an alignment layer are provided at the inner surface side of one substrate 10 of substrates 10 and 20 opposing each other so as to sandwich a liquid crystal layer 30 in that order from the substrate 10 side. A reflector 47 is disposed at the outside surface side of the substrate 10 of a liquid crystal cell 35b formed by providing the electrode and the alignment layer at the inside surface side of a substrate 20 in that order from the other substrate 20 side, or between the substrate 10 and the electrode 15 disposed at the inside surface side. A retardation plate 27 and a polarizing plate 28 are provided at the outside surface side of the substrate 20 in that order from the substrate 20 side. When an angle between the normal line direction P1 with respect to the display surface 1a of the liquid crystal display device 3 and a main viewing direction α is from 0° to 20° , a reflection peak value of light incident upon the liquid crystal display device 3 and reflected by the reflector 47 is set so as to occur within a range of 20° from the normal line direction P1.



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CLAIMS

[Claim(s)]
[Claim 1] An electrode and the orientation film are prepared in the inside side of one substrate of the substrate which counters on both sides of a liquid crystal layer sequentially from one [this] substrate side. A reflector is prepared between the electrodes prepared in the one [said] substrate and inside [the external surface of one / said / substrate of the liquid crystal cell which prepared an electrode and the orientation film in the inside side of the substrate of another side sequentially from the substrate side of this another side, or] side of this. By coming to prepare a phase contrast plate and a polarizing plate in the external surface side of the substrate of said another side sequentially from the substrate side of said another side, when the include angles of the direction of a normal over the screen of this liquid crystal display and the main observation direction to make are 0 times thru/or 20 degrees It is the liquid crystal display which, as for the reflection factor of the reflected light which the incident light which carried out incidence to said liquid crystal display reflected by said reflector, has the peak field where a reflection factor is high focusing on a specular reflection include angle, and is characterized by setting up the peak of the reflection factor of a parenthesis so that it may result [from / said / a normal] within the limits of 30 degrees.
[Claim 2] The liquid crystal display according to claim 1 characterized by setting up the peak of the reflection factor of the reflected light which the incident light which carried out incidence to said liquid crystal display reflected by said reflector so that it may result [from / said / a normal] within the limits of 20 degrees.
[Claim 3] Two or more crevices which have light reflex nature are formed in the front face of the metal membrane in which said reflector was formed on the base material, or a base material. As for these crevices, the inside of a crevice is formed in the range nothing and whose tilt-angle distribution are -30 - +30 degrees in a part of spherical surface, respectively. It is the liquid crystal display according to claim 1 or 2 with which the depth of said crevice is irregularly formed by within the limits which is 0.1 micrometers - 3 micrometers, and it is characterized by having arranged said two or more crevices irregularly at within the limits whose pitch of an adjoining crevice is 2 micrometers - 50 micrometers.
[Claim 4] An electrode and the orientation film are prepared in the inside side of one substrate of the substrate which counters on both sides of a liquid crystal layer sequentially from one [this] substrate side. A reflector is prepared between the electrodes prepared in the one [said] substrate and inside [the external surface of one / said / substrate of the liquid crystal cell which prepared an electrode and the orientation film in the inside side of the substrate of another side sequentially from the substrate side of this another side, or] side of this. By coming to prepare a phase contrast plate and a polarizing plate in the external surface side of the substrate of said another side sequentially from the substrate side of said another side, when the include angles of the direction of a normal over the screen of this liquid crystal display and the main observation direction to make are 0 times thru/or 20 degrees The liquid crystal display characterized by being set up as there is a peak of the reflection factor of the reflected light which the incident light which carried out incidence to said liquid crystal display reflected by said reflector within limits smaller than 30 degrees from [said] a normal.
[Claim 5] The liquid crystal display according to claim 4 characterized by setting up the peak of the

reflection factor of the reflected light which the incident light which carried out incidence to said liquid crystal display reflected by said reflector as it is [said] within the limits of 20 degrees from a normal.
[Claim 6] Two or more crevices which have light reflex nature are formed in the front face of the metal membrane in which said reflector was formed on the base material, or a base material. These crevices are formed, respectively so that a tilt angle (absolute value of the include angle of the tangential plane and base material front face in the point of the arbitration on a curved surface to make) may serve as max by one flank of a crevice. It is the liquid crystal display according to claim 4 or 5 with which the depth of said crevice is irregularly formed by within the limits which is 0.1 micrometers – 3 micrometers, and it is characterized by having arranged said two or more crevices irregularly at within the limits whose pitch of an adjoining crevice is 2 micrometers – 50 micrometers.
[Claim 7] Two or more crevices which have light reflex nature are formed in the front face of the metal membrane in which said reflector was formed on the base material, or a base material. These crevices It has the following specific longitudinal sections where each passes through the vertex of a crevice. Said specific longitudinal section The 1st curve with the configuration of the inside from the periphery of 1 of a crevice to [curve] a vertex, The 2nd curve from the vertex of a crevice to the 3rd curve or a straight line succeeding this 1st curve, It consists of the 3rd curve or straight line which results in other peripheries succeeding this 2nd curve. The average of the absolute value of the tilt angle to the base material front face of said 1st curve is made larger than the average of the absolute value of the tilt angle to the base material front face of the 2nd curve. And it is made larger than the average of the absolute value of the tilt angle to the base material front face of the 3rd curve or a straight line. And the liquid crystal display according to claim 4 or 5 characterized by differing from the average of the absolute value of the tilt angle to the base material front face of the average of the absolute value of a tilt angle and the 3rd curve to the base material front face of the 2nd curve, or a straight line.
[Claim 8] Two or more crevices which have light reflex nature are formed in the front face of the metal membrane in which said reflector was formed on the base material, or a base material. The inside of said crevice consists of a field which the periphery curved surface which are a part of two spherical surfaces from which a radius differs respectively, and the bottom curved surface which exists in the location surrounded by the periphery curved surface were made to follow. The liquid crystal display according to claim 4 or 5 characterized by the normal stood to the reflector front face from the core of each spherical surface existing on a mutually different straight line while the radius of the spherical surface which forms a periphery curved surface is smaller than the radius of the spherical surface which forms a bottom curved surface.
[Claim 9] Said reflector is a liquid crystal display given in claim 4 which has unsymmetrical reflection factor distribution to the specular reflection include angle of incident light, and is characterized by having a reflection property in the light-receiving include-angle range where the maximum of a reflection factor is moreover smaller than the specular reflection include angle of incident light thru/or any 1 term of 8.
[Claim 10] It is the liquid crystal display according to claim 9 characterized by the profile of the graph which shows reflection factor distribution of said reflector being stair-like, and the maximum of said reflection factor existing in the crowning of said stair-like profile.
[Claim 11] A liquid crystal display given in claim 1 characterized by the base material of said reflector or the thickness of a metal membrane being 8nm – 20nm thru/or any 1 term of 10.
[Claim 12] Pocket electronic equipment characterized by equipping a display with a liquid crystal display given in claim 1 thru/or any 1 term of 11.

[Translation done.]

DETAILED DESCRIPTION

[Detailed Description of the Invention]
[0001]
[Field of the Invention] This invention relates to the pocket electronic equipment which equipped the display with the liquid crystal display equipped with the liquid crystal display and such a property of having a viewing-angle property which looks brighter than other viewing angles, when a display is observed with respect to a liquid crystal display and pocket electronic equipment equipped with the reflector from the direction near the direction of a normal over the screen of a liquid crystal display.
[0002]
[Description of the Prior Art] Generally, there are what is called the transflective type equipped with the back light and a transparency mold, and a thing called a reflective mold in the display gestalt of a liquid crystal display. A reflective mold liquid crystal display is a liquid crystal display displayed without a back light only using outdoor daylight, such as sunlight and illumination light, for example, is a thin shape, and that to the Personal Digital Assistant with which lightweight-izing and a low power are demanded are used. [many] Moreover, when a back light is made to turn on in the environment where outdoor daylight is not obtained enough, it operates by the transparent mode and outdoor daylight is obtained enough, a transflective LCD operates in the reflective mode in which a back light is not made to turn on, and that on pocket electronic equipment, such as a cellular phone and a note type personal computer (note type PC), are used. [many]
[0003] Drawing 12 is the sectional view showing the example of the conventional transflective reflective mold liquid crystal display. This transflective reflective mold liquid crystal display on bottom phase contrast plate 73a of the bottom polarizing plate 70 and the reflecting plate 71 with bottom phase contrast plate 73a Liquid crystal cell 72 for reflective mode STN (Super-Twisted Nematic) methods, the forward-scattering plate 90, top phase contrast plate 73b, The laminating of the top polarizing plate 74 is carried out to order from the bottom phase contrast plate 73b side, and, on the other hand, it has outline composition in which the inferior-surface-of-tongue side of a reflecting plate 71 was equipped with the back light 95 as the light source. The laminating of the bottom glass substrate 75, a color filter 76, the bottom transparent electrode layer 78, the bottom orientation film 79, the top orientation film 80 by which opposite arrangement was carried out by separating this bottom orientation film 79 and clearance, the top transparent electrode layer 81, and the top glass substrate 82 is carried out to order from the bottom polarizing plate 70 side, and the liquid crystal cell 72 has outline composition in which the STN LCD layer 83 was arranged between the orientation film 79 of the above bottom and a top, and 80. Between the color filter 76 and the bottom transparent electrode layer 78, the overcoat layer (illustration abbreviation) which consists of a silica or acrylic resin is prepared.
[0004] As for the reflecting plate 71, hole 71a for the front face to consist of aluminum film of a mirror plane condition, and penetrate back light light for a back light 90 at the time of use is formed. The phase contrast plates 73a and 73b are for preventing that a display colors it blue and yellow by compensating the phase contrast of the light which penetrates STN LCD. By scattering over a liquid crystal cell 72 side the incident light (outdoor daylight) which has carried out incidence through the top polarizing plate 74 and top phase contrast plate 73b, the forward-scattering plate 90 is formed in order to make it the

reflected light which incident light reflected on reflecting plate 71 front face reflect not only in the direction of specular reflection but in the direction of [near the specular reflection].
[0005] Moreover, there are some which are shown in drawing 13 as an example of the conventional transflective reflective mold liquid crystal display. This reflective mold liquid crystal display is on the liquid crystal cell 172 for reflective mode STN (Super-Twisted Nematic) methods. The laminating of 1st phase contrast plate 173a, 2nd phase contrast plate 173b, and the polarizing plate 174 is carried out to order from the top glass substrate 182 side, and, on the other hand, it has outline composition in which the inferior-surface-of-tongue side of a liquid crystal cell 172 was equipped with the back light 195 as the light source. The liquid crystal cell 172 has outline composition the laminating of the bottom glass substrate 175, a reflector 171, overcoat layer 171c, a color filter 176, overcoat layer 177a, the bottom transparent electrode layer 178, the bottom orientation film 179, the top orientation film 180 by which opposite arrangement was carried out by separating this bottom orientation film 179 and clearance, topcoat layer 177b, the top transparent electrode layer 181, and the top glass substrate 182 was carried out [composition] to order.
[0006] Much detailed irregularity (drawing 13 crevice 171e ...) adjoins a reflector irregularly, and the reflector 171 is formed in it. Aluminum, silver, etc. are vapor-deposited or plated on the front face of resin base material 171a in which light was irradiated through the mask pattern as the formation approach of the above-mentioned irregularity on the front face of resin base material 171a which consists of a photopolymer layer etc., for example, the detailed spherical-surface-like crevice of a large number which adjoin by the development was formed in, and many such spherical-surface-like crevices were formed, and the approach of forming metal membrane 171b which has irregularity (crevice 171e ...) etc. is learned. It is made for the thickness of metal membrane 171b to have the light from a back light 195 penetrated by making it thin to about 30nm at the time of the transparent mode. The above-mentioned crevice 171 ... An inside is the spherical surface-like and tilt-angle distribution a configuration - It is the range which is 20 - +20 degrees, it considers as within the limits whose depth is 0.1 micrometers - 3 micrometers, and the mutual distance is set up so that it may differ in within the limits whose pitch between adjoining crevices (distance of a center to center) is 5 micrometers - 50 micrometers.
[0007]
[Problem(s) to be Solved by the Invention] By the way, it is required that visibility, like the brightness of ** resolution, ** contrast, and ** screen, the vividness of ** color, and ** angle-of-visibility range are wide etc. should usually be good as display engine performance of a liquid crystal display. Moreover, the liquid crystal display built into the equipment which uses the screen, making it slanting like Personal Digital Assistants, such as a cellular phone and note type PC, is specifically seen [P] the direction near the direction of a normal over the screen generally, and often from the direction of within the limits of 10 degrees from a normal, as shown in drawing 14 . Moreover, the include angle theta of the main observation direction alpha in case an observer (user) generally looks at the screen (screen), and the direction P of a normal to make has much range of 0 times thru/or 20 degrees. Drawing 14 is an explanatory view in the condition that the display 100 which consists of a liquid crystal display uses the cellular phone with which the body 105 was equipped. As for a normal and Q, in drawing 14 , incident light and omega 0 are whenever [incident angle] (for example, 30 degrees). [as opposed to the screen of a display 100 in P] Moreover, for R1, as for the reflected light (specular reflection) when omega is equal, and R2, omega is [whenever / incident angle / whenever / omega 0 and angle-of-reflection / whenever / angle-of-reflection / whenever / incident angle / whenever / angle-of-reflection / omega of the reflected light smaller than omega 0 and R3] the larger reflected light than omega 0 whenever [incident angle].
[0008] An observer's view Ob is concentrated on the direction of the reflected light R2 usually near the direction P of a normal, and a twist concrete target in the direction of within the limits from [P] a normal to 10 degrees so that he can understand also from drawing. On the other hand, the reflected

lights R1 and R3 It is hard to try to become the direction which looks up at the screen from the bottom. Therefore, to make the reflection factor of a small direction of whenever [angle-of-reflection] higher than specular reflection is desired at the same time considering the facilities of use of an observer it secures a large angle of visibility. However, it sets to the conventional liquid crystal display shown in drawing 12 R> 2. It compares with the liquid crystal display of the type which has not formed the forward-scattering plate at the time of reflective mode. Although the range which incident light reflects becomes large, most incident light is those (the peak of a reflection factor is in the include angle of specular reflection, or the include angle near the specular reflection) which is reflected in the direction of specular reflection and its near. Although the display seen from specular reflection and the direction of the circumference of it looks bright, the display seen from other directions looks dark. Moreover, also in the conventional liquid crystal display shown in drawing 13 , most incident light is those (the peak of a reflection factor is in the include angle of specular reflection, or the include angle of the both sides near the specular reflection) which is reflected in the direction of specular reflection and its near, and although the display seen from specular reflection and the direction of the circumference of it looks bright, the display seen from other directions looks dark.

[0009] Therefore, since an observer's view was concentrated in the direction usually near the direction P of a normal as it said previously that the screens, such as a cellular phone with which the display was equipped with the conventional transflective reflective mold display, are seen, it was what is hard to try to serve as a direction which must look at a display from specular reflection and the direction of the circumference of it if a display is dark and tends to look at a bright display on the other hand, and looks up at the screen from the bottom as mentioned above.

[0010] This invention sets to one of the purposes to offer the liquid crystal display which has a viewing-angle property which looks brighter than other viewing angles, when it is made in order to solve the above-mentioned technical problem, and a display is observed from the direction near the direction of a normal over the screen of a liquid crystal display. Moreover, this invention sets to one of the purposes to offer pocket electronic equipment which equipped the display with the liquid crystal display which has the above properties, such as pocket electronic terminals, such as a cellular phone and note type PC.

[0011]

[Means for Solving the Problem] In order to attain the above-mentioned purpose, the liquid crystal display of this invention An electrode and the orientation film are prepared in the inside side of one substrate of the substrate which counters on both sides of a liquid crystal layer sequentially from one [this] substrate side. A reflector is prepared between the electrodes prepared in the one [said] substrate and inside [the external surface of one / said / substrate of the liquid crystal cell which prepared an electrode and the orientation film in the inside side of the substrate of another side sequentially from the substrate side of this another side, or] side of this. By coming to prepare a phase contrast plate and a polarizing plate in the external surface side of the substrate of said another side sequentially from the substrate side of said another side, when the include angles of the direction of a normal over the screen of this liquid crystal display and the main observation direction to make are 0 times thru/or 20 degrees The reflection factor of the reflected light which the incident light which carried out incidence to said liquid crystal display reflected by said reflector It has the peak field where a reflection factor is high focusing on a specular reflection include angle, and is characterized by setting up the peak of the reflection factor of a parenthesis so that it may result [from / said / a normal] within the limits of 30 degrees (it setting up so that the end of the peak field of a reflection factor may exist among 30 degrees from zero light-receiving angle). According to the liquid crystal display of this invention of this configuration, since the amount of reflected lights of the range of within the limits of 30 degrees increases from a normal to the screen of said liquid crystal display, distribution of a direction with the amount of reflected lights near an observer's view also becomes high, and the include angle of said direction of a normal and main observation direction to make can realize the liquid crystal display of a bright display (screen) in 0 times thru/or 20 degrees especially in the view of practical use.

[0012] In the liquid crystal display of this invention of the above-mentioned configuration, it is desirable that the peak of the reflection factor of the reflected light which the incident light which carried out incidence to said liquid crystal display reflected by said reflector is set up so that it may result [from / said / a normal] within the limits of 20 degrees (it sets up so that the end of the peak field of a reflection factor may exist among 20 degrees from zero light-receiving angle). According to the liquid crystal display of this invention of this configuration, the amount of reflected lights of the range of within the limits of 20 degrees increases from a normal to the screen of said liquid crystal display. Since distribution of a direction with the amount of reflected lights near an observer's view also becomes high and the field where the amount of reflected lights is high moreover spreads, in the view of practical use, the include angle of said direction of a normal and main observation direction to make can realize the liquid crystal display of a bright display (screen) in 0 times thru/or 20 degrees especially.
[0013] As an example of the implementation means of a liquid crystal display equipped with the above properties As said reflector, two or more crevices which have light reflex nature are formed in the front face of the metal membrane formed on the base material, or a base material. As for these crevices, the inside of a crevice is formed in the range nothing and whose tilt-angle distribution are -30 - +30 degrees in a part of spherical surface, respectively. The depth of said crevice is irregularly formed by within the limits which is 0.1 micrometers - 3 micrometers, and said two or more crevices can be realized by using the thing of a configuration of that the pitch of an adjoining crevice was irregularly made arrangement by within the limits which is 2 micrometers - 50 micrometers.
[0014] In order to attain the above-mentioned purpose, moreover, the liquid crystal display of this invention An electrode and the orientation film are prepared in the inside side of one substrate of the substrate which counters on both sides of a liquid crystal layer sequentially from one [this] substrate side. A reflector is prepared between the electrodes prepared in the one [said] substrate and inside [the external surface of one / said / substrate of the liquid crystal cell which prepared an electrode and the orientation film in the inside side of the substrate of another side sequentially from the substrate side of this another side, or] side of this. By coming to prepare a phase contrast plate and a polarizing plate in the external surface side of the substrate of said another side sequentially from the substrate side of said another side, when the include angles of the direction of a normal over the screen of this liquid crystal display and the main observation direction to make are 0 times thru/or 20 degrees The peak of the reflection factor of the reflected light which the incident light which carried out incidence to said liquid crystal display reflected by said reflector is characterized by being set up as it is within limits smaller than 30 degrees from [said] a normal. Since the amount of reflected lights of within the limits smaller than 30 degrees increases from [to the screen of said liquid crystal display] a normal according to the liquid crystal display of this invention of this configuration, distribution of a direction with the amount of reflected lights near an observer's view becomes high, and the include angle of said direction of a normal and main observation direction to make can realize the liquid crystal display of a bright display (screen) in 0 times thru/or 20 degrees especially in the view of practical use.
[0015] In the liquid crystal display of this invention of the above-mentioned configuration, it is desirable that the peak of the reflection factor of the reflected light which the incident light which carried out incidence to said liquid crystal display reflected by said reflector is set up as it is [said] within the limits of 20 degrees from a normal. According to the liquid crystal display of this invention of this configuration, the amount of reflected lights within the limits of 20 degrees increases from a normal to the screen of said liquid crystal display. Since distribution of a direction with the amount of reflected lights near an observer's view becomes high and the field where the amount of reflected lights is high moreover spreads, in the view of practical use, the include angle of said direction of a normal and main observation direction to make can realize the liquid crystal display of a bright display (screen) in 0 times thru/or 20 degrees especially.
[0016] As the first example of the implementation means of a liquid crystal display equipped with the above properties As said reflector, two or more crevices which have light reflex nature are formed in the

front face of the metal membrane formed on the base material, or a base material. These crevices are formed, respectively so that a tilt angle (absolute value of the include angle of the tangential plane and base material front face in the point of the arbitration on a curved surface to make) may serve as max by one flank of a crevice. The depth of said crevice is irregularly formed by within the limits which is 0.1 micrometers – 3 micrometers, and said two or more crevices can be realized by using the thing of a configuration of that the pitch of an adjoining crevice has been irregularly arranged by within the limits which is 2 micrometers – 50 micrometers. As the second example of the implementation means of a liquid crystal display equipped with the above properties As said reflector, two or more crevices which have light reflex nature are formed in the front face of the metal membrane formed on the base material, or a base material. These crevices It has the following specific longitudinal sections where each passes through the vertex of a crevice. Said specific longitudinal section The 1st curve with the configuration of the inside from the periphery of 1 of a crevice to [curve] a vertex, The 2nd curve from the vertex of a crevice to the 3rd curve or a straight line succeeding this 1st curve, It consists of the 3rd curve or straight line which results in other peripheries succeeding this 2nd curve. The average of the absolute value of the tilt angle to the base material front face of the 1st curve is made larger than the average of the absolute value of the tilt angle to the base material front face of the 2nd curve. And it is made larger than the average of the absolute value of the tilt angle to the base material front face of the 3rd curve. And it is realizable by using what was made a different configuration from the average of the absolute value of the tilt angle to the base material front face of the average of the absolute value of a tilt angle and the 3rd curve to the base material front face of the 2nd curve, or a straight line. As the third example of the implementation means of a liquid crystal display equipped with the above properties As said reflector, two or more crevices which have light reflex nature are formed in the front face of the metal membrane formed on the base material, or a base material. The inside of said crevice consists of a field which the periphery curved surface which are a part of two spherical surfaces from which a radius differs respectively, and the bottom curved surface which exists in the location surrounded by the periphery curved surface were made to follow. While the radius of the spherical surface which forms a periphery curved surface is smaller than the radius of the spherical surface which forms a bottom curved surface, it is realizable by using the thing of a configuration of that the normal stood to the reflector front face from the core of each spherical surface exists on a mutually different straight line.

[0017] Moreover, in the liquid crystal display of this invention of one of the aforementioned configurations, said reflector has unsymmetrical reflection factor distribution to the specular reflection include angle of incident light, and it is characterized by equipping the maximum of a reflection factor with the reflection property which is in the range (light–receiving include–angle range) whenever [smaller than specular reflection include angle of incident light angle–of–reflection]. According to the liquid crystal display of this invention of this configuration, since the amount of reflected lights of the light–receiving include–angle range smaller than a specular reflection include angle increases, distribution of the direction near an observer's view becomes high, and the amount of reflected lights can realize the liquid crystal display of a bright display (screen) in the view of practical use. Moreover, the profile of the graph which shows reflection factor distribution of said reflector is stair–like, and, as for the maximum of said reflection factor, it is desirable to exist in the crowning of said stair–like profile. According to the liquid crystal display equipped with the reflector which shows such reflection factor distribution, since the reflection factor of the specific include–angle range in the range (light–receiving include–angle range) becomes still higher whenever [smaller than specular reflection include angle angle–of–reflection], distribution of the direction near an observer's view becomes high, and the amount of reflected lights can realize the liquid crystal display of a bright display (screen) in the view of practical use. Moreover, it sets to the liquid crystal display of this invention of one of the aforementioned configurations. When said reflector consists of a metal membrane which has a base material and two or more crevices formed on this When the thickness of a metal membrane becomes thin, the translucency of the light from a back light prepared in the lower part side of said reflector can be raised and light is reflected by making

thickness of said metal membrane into within the limits of 8nm – 20nm, It can be used [in both cases of making light penetrate] as a transflective reflective mold liquid crystal display which demonstrates the outstanding property. Moreover, by making thickness of said base material into within the limits of 8nm – 20nm, when said reflector consists of a base material which has two or more crevices, the thickness of a base material can become thin, the translucency of the light from a back light prepared in the lower part side of said reflector can be raised, and it can be used as a transflective reflective mold liquid crystal display which demonstrates the outstanding property [in both the case where light is reflected, and the case of making light penetrate].

[0018] In order to attain the above-mentioned purpose, the pocket electronic equipment of this invention is characterized by equipping a display with the liquid crystal display of this invention of one of the above-mentioned configurations. According to the pocket electronic equipment of this invention of this configuration, pocket electronic equipment which was excellent in the visibility of the screen (screen) also in actuation in reflective mode or actuation [which / of reflective mode and the transparent mode], such as a cellular phone and note type PC, can be obtained.

[0019]

[Embodiment of the Invention] Hereafter, although the gestalt of operation of this invention is explained with reference to a drawing, this invention is not limited to the gestalt of the following operations.

(1st operation gestalt) Drawing 1 is drawing having shown typically partial cross-section structure including the edge of the transflective reflective mold liquid crystal display which is the 1st operation gestalt of this invention. In drawing 1 , the transflective reflective mold liquid crystal display 1 of this invention is the configuration which carried out the adhesion unification of the 1st substrate (one substrate) 10 which consists of transparent glass which pinches the liquid crystal layer 30 and counters, and the 2nd substrate (substrate of another side) 20 by the sealant 40 which was able to be annularly prepared in the periphery section of these two substrates 10 and 20. In order, laminating formation of a reflector 7, the color filter 13 for performing color display, the overcoat film 14 for carrying out flattening of the irregularity by the reflector 7 or the color filter 13, while covering and protecting a reflector 7, the transparent electrode layer 15 for driving the liquid crystal layer 30, and the orientation film 16 for controlling the orientation of the liquid crystal molecule which constitutes the liquid crystal layer 30 is carried out at the liquid crystal layer 30 side of the 1st substrate 10. Moreover, laminating formation of the transparent electrode layer 25, the overcoat film 24, and the orientation film 26 is carried out at the liquid crystal layer 30 side of the 2nd substrate 20 at order.

[0020] The liquid crystal cell 35 is constituted by each configuration member prepared between the 1st above-mentioned substrate 10, the 2nd substrate 20, and these substrates. The polarizing plate 18 is formed in the opposite side (external surface side of the 1st substrate 10) the liquid crystal layer 30 side of the 1st substrate 10, and the laminating of the phase contrast plate 27 and the polarizing plate 28 is carried out to the opposite side (external surface side of the 2nd substrate 20) in this order the liquid crystal layer 30 side of the 2nd substrate 20. The lateral surface of a polarizing plate 28 is screen 1a. Moreover, the back light 5 as the light source for performing a transparency display in the transflective liquid crystal display 1 is arranged in the outside of the polarizing plate 18 of the 1st substrate 10.

[0021] moreover, in this transflective reflective mold liquid crystal display 1 When the include angles theta 1 of the direction P1 of a normal over screen 1a of this liquid crystal display 1 and the main observation direction alpha 1 to make are 0 times thru/or 20 degrees The peak of the reflection factor of the reflected light which the incident light which carried out incidence to the liquid crystal cell 35 reflected by the reflector 7 is set up so that it may result [from / P1 / a normal] within the limits of 30 degrees, and preferably, the peak of the reflection factor of the above-mentioned reflected light is set up so that it may result [from / P1 / a normal] within the limits of 20 degrees.

[0022] The above-mentioned reflector 7 consists of organic film (base material) 11 and metallic reflection film (metal membrane) 12 formed on this organic film 11. The organic film 11 is formed in order

to give the shape of toothing to the metallic reflection film 12 currently formed on it and to scatter the reflected light efficiently. Thus, since the light which carried out incidence to the liquid crystal display 1 by giving the shape of toothing to the metallic reflection film 12 can be reflected efficiently, the bright display in reflective mode is realizable. Drawing 2 is the perspective view showing the reflector 7 equipped with the organic film 11 and the metallic reflection film 12 formed on it. As shown in this drawing, as crevice 12A of a large number to which that inside makes a part of spherical surface overlaps right and left, it is continuously formed in the front face of the organic film 11, and the laminating of the metallic reflection film 12 is carried out on that field.

[0023] The depth of the above-mentioned crevice 12A is formed at random in 0.1 micrometers - 3 micrometers, the pitch of adjoining crevice 12A is arranged at random in 2 micrometers - 50 micrometers, and the tilt angle of the above-mentioned crevice 12A inside is set as the range of -30 - +30 degrees. The point of setting tilt-angle distribution of a crevice 12A inside as the range of -30 - +30 degrees especially, and especially the point that arranges the pitch of adjoining crevice 12A at random to all the flat-surface directions are important. It is because there is fault that the interference color of light will come out and the reflected light will color when regularity is in the pitch of crevice 12A which adjoins temporarily. Moreover, when tilt-angle distribution of a crevice 12A inside exceeds the range which is -30 - 30 degrees, the diffusion angle of the reflected light spreads too much, reflectivity falls, and it is [that a bright display is not obtained and] (it is because the diffusion angle of the reflected light becomes 36 degrees or more in air, the reflectivity peak inside a liquid crystal display falls and a total reflection loss becomes large.). The reflection property set as this liquid crystal display 1 is changed (for example, the peak of the reflection factor of the reflected light from the reflection property it is made to result [from / P1 / a normal] within the limits of 30 degrees). In order for the peak of the reflection factor of the reflected light to carry out [P1] from a normal by making it the reflection property it is made to result within the limits of 20 degrees It is possible by changing tilt-angle distribution of for example, a crevice 12A inside into a different thing as a reflector 7 with which a liquid crystal display 1 is equipped (however, tilt-angle distribution of a crevice 12A inside is within the limits of the above).

[0024] Moreover, if the depth of crevice 12A exceeds 3 micrometers, when carrying out flattening of the crevice 12A at a back process, the summit of heights cannot finish burying by the flattening film (overcoat film 14), desired surface smoothness will no longer be obtained, and it will become the cause of display unevenness. When the pitch of adjoining crevice 12A is less than 2 micrometers, there is constraint on manufacture of the imprint mold used in order to form the organic film 11, and the problem of that only the configuration where a desired reflection property is obtained cannot be formed, an interference light occurring that floor to floor time becomes very long arises. Moreover, when using practically the diamond indenter of the diameter of 5 micrometers - 100 micrometer which can be used for manufacture of said imprint mold, it is desirable to set the pitch of adjoining crevice 12A to 2 micrometers - 50 micrometers.

[0025] After the organic film (base material) 11 applies photopolymer liquid, such as an acrylic resist, with a spin coat method etc. on the 1st substrate 10, it is prebaked, forms a photopolymer layer, an imprint mold equipped with the field which consists of a concave convex which has the shape of toothing, and a flat side of the periphery is pushed against the front face of the above-mentioned photopolymer layer, and imprints the configuration of the concave convex of the above-mentioned imprint mold on the front face of a photopolymer layer, and is obtained. It can be desirable to use a metallic material with high reflection factors, such as aluminum and Ag, for the metallic reflection film 12, and it can **** these metallic materials by the forming-membranes methods, such as sputtering and vacuum deposition. As for the thickness of the metallic reflection film 12, it is desirable that it is the range of 8nm - 50nm (80A - 500A). When thickness is thinner than 8nm, since this has the too small reflection factor of the light by the metallic reflection film 12, it is because the display at the time of reflective mode becomes dark, and when thicker than 50nm, it is because the translucency of the

metallic reflection film 12 falls and the display at the time of the transparent mode becomes dark.
[0026] Moreover, as for the thickness of the metallic reflection film 12, it is more desirable that it is the range of 8nm – 30nm (80A – 300A). If thickness of the metallic reflection film 12 is made into such range, since an indication at the time of the transparent mode can be given bright, the difference of the brightness of the display at the time of the transparent mode and reflective mode can be made small. Therefore, the conspicuousness of the display at the time of using it, changing said two modes of operation can be raised. Furthermore, as for the thickness of the metallic reflection film 12, it is most desirable that it is the range of 8nm – 20nm (80A – 200A). By setting it as the thickness of such range, the brightness at the time of reflective mode can be held, and exceptionally excellent brightness can be realized at the time of the transparent mode.
[0027] The electrode layer 15 is what carried out alignment formation of many things of the flat-surface configuration of the shape of a strip of paper which consists of transparence electric conduction film, such as ITO (Indium tin oxide), and since the liquid crystal molecule which is connected separately in an external drive circuit (not shown), and constitutes the liquid crystal layer 30 is driven, it is formed in the overcoat film 14. Alignment formation of many things of the strip-of-paper-like flat-surface configuration where the electrode layer 25 consists of transparence electric conduction film, such as ITO, similarly is carried out on a substrate 20, and it connects separately in the external drive circuit. In addition, the electrode layer 15 and the electrode layer 25 are arranged so that a plane view right angle may be turned to mutually, and let the above-mentioned liquid crystal display 1 be a passive matrix mold.
[0028] In the transflective reflective mold liquid crystal display 1 of this operation gestalt By having had the reflector 7 in which two or more crevice 12A of the above-mentioned configuration was formed The peak of the reflection factor of the reflected light which the incident light which carried out incidence to the liquid crystal cell 35 reflected by the reflector 7 Since it is set up so that it may result [from / P1 / a normal] within the limits of 30 degrees, and the amount of reflected lights of the range of within the limits of 30 degrees increases [P1] from a normal to screen 1a of a liquid crystal display 1 at the time of reflective mode Distribution of a direction with the amount of reflected lights near an observer's view Ob1 also becomes high, and the include angle theta 1 of the direction P1 of a normal and the main observation direction alpha 1 to make can realize the liquid crystal display of a bright display (screen) in 0 times thru/or 20 degrees especially in the view of practical use.
[0029] Moreover, if the peak of the reflection factor of the reflected light which the incident light which carried out incidence to the liquid crystal cell 35 especially reflected by the reflector 7 is one of those which were set up so that it might result [from / P1 / a normal] within the limits of 20 degrees At the time of reflective mode, the amount of reflected lights of the range of within the limits of 20 degrees increases [P1] from a normal to screen 1a of a liquid crystal display 1. Since distribution of a direction with the amount of reflected lights near an observer's view Ob1 also becomes high and the field where the amount of reflected lights is high moreover spreads, in the view of practical use, the include angle of the direction P1 of a normal and the main observation direction alpha 1 to make can realize the liquid crystal display of a bright display (screen) in 0 times thru/or 20 degrees especially.
[0030] Moreover, in spite of using the metallic reflection film 12 of thin thickness for the transflective reflective mold liquid crystal display 1 of this operation gestalt, since the display of brightness sufficient at the time of reflective mode can be obtained and the metallic reflection film 12 is made thin, an exceptionally bright display is obtained in the transparent mode. This is because the configuration of point ** is formed in the front face of the organic film 11. That is, although the reflection factor of the metallic reflection film 12 itself will fall if the metallic reflection film 12 is made thin and translucency is raised, the bright display at the time of the transparent mode can be realized by raising the reflective effectiveness of the light by the metallic reflection film 12 to the maximum, when an inside forms in the front face of the organic film 11 continuously crevice 12A of a large number which make a part of spherical surface, without spoiling greatly the brightness of the display at the time of reflective mode. Moreover, if the metallic reflection film 12 is set to 8nm – 20nm, the liquid crystal display 1 of this

operation gestalt can realize an exceptionally bright display in the transparent mode. Only improvement in the translucency by the metallic reflection film 12 being very thin is not realized, and this is because the effectiveness by the configuration of the organic film 11 above-mentioned front face was added. that is, by the lens effectiveness's acting on the organic film 11 to the light which carries out incidence from a substrate 10 side, when the inside of crevice 12A formed in the front face of the organic film 11 is the spherical surface as shown in drawing 2 , and reinforcing the light from a back light 5 which passes the organic film 11, it can be markedly alike and a bright display can be obtained.

[0031] In addition, although the above-mentioned operation gestalt explained the case where the liquid crystal display of this invention was applied to the transflective reflective mold liquid crystal display of a passive matrix mold, this invention is not limited to this and can be applied also to the liquid crystal display of a active-matrix mold. What is necessary is just to prepare the reflector by which two or more crevices which have light reflex nature on the front face of a publication were previously formed on the pixel electrode which constitutes a pixel in that case, or in the bottom.

[0032] Although drawing 3 has not prepared the back light with the liquid crystal display 1 of the 1st operation gestalt, to screen 1a Outdoor daylight is irradiated at 30 degrees (include angle with the optical axis of the outdoor daylight illuminated from the opposite side of the view Ob1 of the observer who observes a display from one perpendicular (normal) side stood to screen 1a to make) of incident angles. The relation between the light-receiving angle (degree) when shaking the observation direction alpha (light-receiving angle) from a perpendicular location (normal location) (0 degree) to 60 degrees and brightness (reflection factor) is shown. Continuous-line ** and ** show the relation between the light-receiving angle of the liquid crystal display of the 1st operation gestalt, and a reflection factor among drawing 3 , and the difference in the thing of continuous-line ** and ** is the point that the depth of crevice 12a of a reflector 7 etc. differs. At drawing 3 , broken-line ** showed the relation between the light-receiving angle of the thing of a type which has not prepared the back light with the liquid crystal display shown in drawing 12 or drawing 13 R> 3 used from the former as an example of a comparison, and a reflection factor.

[0033] It is thought that the display seen from other directions although the display seen from specular reflection since the reflection factor is sharply and small, if the peak of a reflection factor is in the include angle (30 degrees of light-receiving angles) of specular reflection in the liquid crystal display of the example of a comparison so that clearly from drawing 3 , and it becomes small [20 degrees of light-receiving angles] looked bright looks dark. on the other hand, in the liquid crystal display 1 of the 1st operation gestalt which has the property shown by continuous-line ** The peak field where especially a reflection factor is high existed focusing on 30 degrees (specular reflection include angle) of light-receiving angles, and, moreover, the peak of this reflection factor is prolonged within the limits of 20 degrees from the normal (in other words, the end of the peak field of a reflection factor exists among 20 degrees from 0 degree of light-receiving angles.). (0 degree of light-receiving angles) From things, the high reflection factor is shown compared with the example of a comparison in 20 degrees - 0 degree of light-receiving angles, and when a display is observed from the direction near the direction of a normal, it is thought that a display looks bright from the thing of the example of a comparison. moreover -- the liquid crystal display 1 of the 1st operation gestalt which has the property shown by continuous-line ** -- the peak of a reflection factor --**of 30 degrees of light-receiving angles -- it is crossing to the large range of about 10 degrees. moreover, in the liquid crystal display 1 of the 1st operation gestalt which has the property shown by continuous-line ** The peak field where especially a reflection factor is high existed focusing on 30 degrees of light-receiving angles, and, moreover, the peak of this reflection factor is prolonged within the limits of 10 degrees from the normal (in other words, the end of the peak field of a reflection factor exists among 10 degrees from 0 degree of light-receiving angles.). (0 degree of light-receiving angles) From things, the high reflection factor is shown compared with the example of a comparison in 10 degrees - 0 degree of light-receiving angles, and when a display is observed from the direction near the direction of a normal, it is thought that a display looks bright from

the thing of the example of a comparison. moreover -- the liquid crystal display 1 of the 1st operation gestalt which has the property shown by continuous-line ** -- the peak of a reflection factor --**of 30 degrees of light-receiving angles -- it is crossing to the large range of about 20 degrees. For this reason, especially visibility will become good if the liquid crystal display of this operation gestalt is built into the liquid crystal display of this operation gestalt of one of the above-mentioned configurations at the display of pocket electronic equipment, such as a cellular phone and note type PC.

[0034] (2nd operation gestalt) In the operation gestalt of the above 1st, although the case of the attachment type in a reflector which contained the reflector 7 in which the light which carried out incidence from the outside is reflected between the substrate 10 and the substrate 20 was explained, it can also consider as the reflector external type which prepared the reflector in the outside of two substrates which pinched the liquid crystal layer. This configuration is made into the 2nd operation gestalt of this invention, and it explains below with reference to drawing 4 . In addition, the same sign is given to the same component as the 1st operation gestalt, and explanation is simplified to it.

[0035] Drawing 4 is drawing showing the partial cross-section structure of the transflective reflective mold liquid crystal display 2 which is the 2nd operation gestalt of this invention. The place where the transflective reflective mold liquid crystal display 2 of the 2nd operation gestalt differs from the transflective reflective mold liquid crystal display 1 of the 1st operation gestalt is the point that the overcoat film 14, a color filter 13, and a reflector 7 are not formed between the 1st substrate 10 and an electrode 15, but the same reflector 7 as what was explained with the 1st operation gestalt is formed between the 1st substrate 10 and a back light 5. Liquid crystal cell 35a is constituted by each configuration member prepared between the 1st substrate 10, the 2nd substrate 20, and these substrates.

[0036] In the transflective reflective mold liquid crystal display 2 of this operation gestalt When the include angles theta 1 of the direction P1 of a normal over screen 1a of this liquid crystal display 2 and the main observation direction alpha 1 to make are 0 times thru/or 20 degrees like the 1st operation gestalt The peak of the reflection factor of the reflected light which the incident light which carried out incidence through liquid crystal cell 35a reflected by the reflector 7 is set up so that it may result [from / P1 / a normal] within the limits of 30 degrees. Preferably The peak of the reflection factor of the above-mentioned reflected light is set up so that it may result [from / P1 / a normal] within the limits of 20 degrees. In addition, although not illustrated between the 1st substrate 10 of the above, and an electrode 15, it is made to carry out by forming a color filter layer by approaches, such as printing, color display of this liquid crystal display 2.

[0037] In the transflective reflective mold liquid crystal display 2 of this operation gestalt By having had the reflector 7 in which two or more crevice 12A of the above-mentioned configuration was formed The peak of the reflection factor of the reflected light which the incident light which carried out incidence through liquid crystal cell 35a reflected by the reflector 7 Since it is set up so that it may result [from / P1 / a normal] within the limits of 30 degrees, and the amount of reflected lights of the range of within the limits of 30 degrees increases [P1] from a normal to screen 1a of a liquid crystal display 2 at the time of reflective mode Distribution of a direction with the amount of reflected lights near an observer's view Ob1 also becomes high, and the include angle theta 1 of the direction P1 of a normal and the main observation direction alpha 1 to make can realize the liquid crystal display of a bright display (screen) in 0 times thru/or 20 degrees especially in the view of practical use.

[0038] Moreover, the peak of the reflection factor of the reflected light which the incident light which carried out incidence through liquid crystal cell 35a especially reflected by the reflector 7 If it is in some which were set up so that it might result [from / P1 / a normal] within the limits of 20 degrees At the time of reflective mode, the amount of reflected lights of the range of within the limits of 20 degrees increases [P1] from a normal to screen 1a of a liquid crystal display 2. Since distribution of a direction with the amount of reflected lights near an observer's view Ob1 also becomes high and the field where the amount of reflected lights is high moreover spreads, in the view of practical use, the include angle of

the,direction P1 of a normal and the main observation direction alpha 1 to make can realize the liquid crystal display of a bright display (screen) in 0 times thru/or 20 degrees especially. moreover -- since the reflector 7 used with this operation gestalt 2 can be arranged in the outside of the substrate which constitutes a liquid crystal cell, if it is the liquid crystal display of a transparency mold -- satisfactory -- equipping -- reflective mode and the transparent mode -- also in any, the transflective high-reflective-liquid-crystal equipment in which a bright display is possible can be formed. In addition, in the gestalt of implementation of the above 2nd, although the example which applied this invention to the transflective reflective mold liquid crystal display of a passive matrix mold was explained, this invention is applicable also about the liquid crystal display of 3 terminal mold (TFT: thin film transistor) active-matrix mold and 2 terminal mold active-matrix mold satisfactory. in addition, above-mentioned the 1- in the 2nd operation gestalt, although the case where a polarizing plate 18 was formed in the outside of the 1st substrate 10 was explained, a polarizing plate 18 does not need to prepare in the outside of the 1st substrate 10, and it is adjusted so that a good display property may be acquired in that case in the optical conditions of each part material which constitutes a liquid crystal display. moreover, above-mentioned the 1- in the 2nd operation gestalt, although the case where the liquid crystal display of this invention was applied to a transflective reflective mold liquid crystal display was explained, it can apply also to a reflective mold liquid crystal display, it is not necessary to form a back light 5 in that case and, and the thickness of the metallic reflection film 12 may be thicker than 50nm.

[0039] (3rd operation gestalt) Drawing 5 is drawing having shown typically the partial cross-section structure of the reflective mold liquid crystal display which is the 3rd operation gestalt of this invention. In drawing 5 , this reflective mold liquid crystal display 3 is the configuration which carried out the adhesion unification of the 1st substrate (one substrate) 10 which consists of transparent glass which pinches the liquid crystal layer 30 and counters, and the 2nd substrate (substrate of another side) 20 by the sealant which was able to be annularly prepared in the periphery section of these two substrates 10 and 20. Laminating formation of the orientation film 16 for controlling the orientation of the liquid crystal molecule which constitutes the overcoat film (transparence flattening layer) 14 for carrying out flattening of the irregularity by the reflector 47, the transparence mediation layer 53, the color filter 13 for performing color display, and the color filter 13, the transparent electrode layer 15 for driving the liquid crystal layer 30, and the liquid crystal layer 30 in order is carried out at the liquid crystal layer 30 side of the 1st substrate 10. Moreover, laminating formation of the transparent electrode layer 25, the overcoat film 24, and the orientation film 26 is carried out at the liquid crystal layer 30 side of the 2nd substrate 20 at order.

[0040] Liquid crystal cell 35b is constituted by each configuration member prepared between the 1st above-mentioned substrate 10, the 2nd substrate 20, and these substrates. The polarizing plate 18 is formed in the opposite side (external surface side of the 1st substrate 10) the liquid crystal layer 30 side of the 1st substrate 10, and the laminating of the phase contrast plate 27 and the polarizing plate 28 is carried out to the opposite side (external surface side of the 2nd substrate 20) in this order the liquid crystal layer 30 side of the 2nd substrate 20. The lateral surface of this polarizing plate 28 is screen 1a. Moreover, in this reflective mold liquid crystal display 3, when the include angles theta 1 of the direction P1 of a normal over screen 1a of this liquid crystal display 3 and the main observation direction alpha 1 to make are 0 times thru/or 20 degrees The peak of the reflection factor of the reflected light which the incident light which carried out incidence to liquid crystal cell 35b reflected by the reflector 47 is set up as it is within limits smaller than 30 degrees from [P1] a normal. Preferably The peak of the reflection factor of the above-mentioned reflected light is set up as it is [P1] within the limits of 20 degrees from a normal.

[0041] In preparation for the reflective mold liquid crystal display 3, Crevices 63a, 63b, and 63c and ... (generally a crevice 63 is called) which have many light reflex nature adjoin mutually irregularly the front face (datum level H) of the plate-like base material 61 which consists of aluminum as shown in drawing 6 , and the **** reflector 47 is formed in it.

[0042] As these crevices 63 show a perspective view to drawing 7 and show it to drawing 8 , they have the concave surface of a plane view round shape for a sectional view. This concave surface The aspheric surface of the spoon form where the vertex shown all over [D] drawing shifted from the core O of said plane view round shape to the one direction (the direction of Y) Nothing, It is formed so that the tilt angle (absolute value of the include angle of the tangential plane P and the base material front face H in the point of the arbitration on a curved surface to make) delta may become max, i.e., maximum-angle-of-inclination deltamax, by the 1 flank A. Therefore, tilt-angle deltab in the flank B which serves as the opposite side across Core O in a concave surface with Flank A is smaller than the tilt angle (maximum-angle-of-inclination deltamax) of Flank A. the reflector 47 which it had with this operation gestalt -- setting -- Crevices 63a, 63b, and 63c -- each maximum-angle-of-inclination deltamax in ... differs within the limits of 2 degrees - 90 degrees irregularly. However, many crevices differ in within the limits whose maximum-angle-of-inclination deltamax is 4 degrees - 35 degrees irregularly.

[0043] Moreover, this crevice 63 has the minimum point (point on the curved surface where a tilt angle serves as zero) D that that concave surface is single. And this minimum point D and distance with the datum level H of a base material form depth d of a crevice 63, and this depth d differs within the limits of 0.1 micrometers - 3 micrometers irregularly about Crevices 63a, 63b, and 63c and --, respectively. Moreover, Crevices 63a, 63b, and 63c are irregularly arranged by within the limits whose pitch of an adjoining crevice is 2 micrometers - 50 micrometers.

[0044] In this operation gestalt, as shown in drawing 9 , each aforementioned crevices 63a, 63b, and 63c and -- are formed so that the flank A which has maximum-angle-of-inclination deltamax of each concave surface may gather in the direction of the direction Y distant from an observer's view Ob1. Although the reflected light is diffused in the range of an angle of visibility large as a whole since incidence of the outdoor daylight is generally carried out to a crevice 63 from various directions and it reflects in the various directions according to the tilt angle of a probe index on the curved surface of a crevice 63 When the direction of the reflection is pursued from Oa paying attention to the outdoor daylight which carries out incidence as shown in drawing 10 for example, the reflected light has the inclination for more light to incline and gather in the range of W (clear vision range) shown in drawing 10 by the side of a direction opposite to the flank A which has maximum-angle-of-inclination deltamax, i.e., an observer. Therefore, if an observer's view Ob1 is kept within the limits of this clear vision range W, compared with the case where it observes from other directions, it comes to look more brightly. Since in other words an observer's view Ob1 is concentrated on the direction usually near the direction P1 of a normal of screen 1a, and a twist concrete target in the direction of within the limits from [P1] a normal to 20 degrees If it sets up so that more light may gather in this range (design), when it will observe from the direction near the direction P1 of a normal over screen 1a of a liquid crystal display, compared with the case where it observes from other directions, it comes to look more brightly. The breadth and the direction of this clear vision range W are controllable by adjusting the configuration and the array direction of a crevice 63.

[0045] In the reflector 47 of this operation gestalt, since each crevice 63 is formed in the aspheric surface which has the single minimum point, it does not look so strongly that change of the angle of reflection of light is smooth and the reflected light is dazzling in a specific viewing angle. Although maximum-angle-of-inclination deltamax is made into within the limits of 2 degrees - 90 degrees, there are many things of each crevices 63a, 63b, and 63c and -- made into within the limits of 4 degrees - 35 degrees especially. Therefore, although the light which carried out incidence all over the crevice 63 is broadly scattered about in the range which does not become if the reflected light is at futility and is bright in a field of view as a whole When much light is inclined and reflected especially in a specific angle of visibility (the direction of within the limits smaller than 30 degrees from [P1] a normal, especially the direction of within the limits from [P1] a normal to 20 degrees) and it observes within this angle of visibility (in the view of practical use) When the include angle of said direction of a normal and main

observation direction to make observes in 0 times thru/or 20 degrees especially, it looks brightly especially. Since the depth of a crevice 63 is irregularly formed within the limits of 0.1 micrometers - 3 micrometers, and each crevice 63 adjoins irregularly and is arranged, when it includes in a reflective mold liquid crystal display, a moire pattern does not occur, and peak-concentration of the amount of reflected lights in a specific viewing angle is eased, and change of the amount of reflected lights within a field of view is gently-sloping.

[0046] It is equipped with the above-mentioned reflector 47 so that the direction of each crevices 63a, 63b, and 63c and the flank A of -- which has a maximum angle of inclination may become a side (the direction of Y) far from an observer's view Ob1, as shown in drawing 9 . Moreover, the transparent electrode layer 15 whose liquid crystal layer 30 is pinched, and the transparent electrode layer 25 constitute the liquid crystal equipment of the simple matrix type with which it is formed in the shape of [which intersects perpendicularly mutually] a stripe, and the intersection field serves as a pixel.

[0047] In the reflective mold liquid crystal display 3 of this operation gestalt, if outdoor daylight carries out incidence to screen 1a, incident light enters in liquid crystal panel 35b, penetrates each class, and arrives at the front face of a reflector 47, and according to the crevices 63a, 63b, and 63c of a reflector 47, and the curved surface of --, it will reflect in whenever [wide angle], and it will penetrate said each class again, and it will carry out outgoing radiation from screen 1a. Since these outgoing radiation light is scattered on the large angle-of-visibility range, from a large viewing angle, the light source can be reflected, this screen 1a can be observed that there is nothing, but when observing from the view Ob1 direction of the opposite side and the include angle of said direction P1 of a normal and main observation direction alpha 1 to make observes at 0 times thru/or 20 degrees especially, the brightness of a screen serves as the direction Y of orientation with max.

[0048] By having had the reflector 47 in which two or more crevices 63 of the above-mentioned configuration were formed in the reflective mold liquid crystal display 3 of this operation gestalt The peak of the reflection factor of the reflected light which the incident light which carried out incidence to liquid crystal cell 35b reflected by the reflector 47 Since it is set up as it is within limits smaller than 30 degrees from [P1] a normal, and the amount of reflected lights of within the limits smaller than 30 degrees increases from [to screen 1a of a liquid crystal display 3 / P1] a normal at the time of reflective mode Distribution of a direction with the amount of reflected lights near an observer's view Ob1 also becomes high, and the include angle theta 1 of the direction P1 of a normal and the main observation direction alpha 1 to make can realize the liquid crystal display of a bright display (screen) in 0 times thru/or 20 degrees especially in the view of practical use.

[0049] Moreover, if the peak of the reflection factor of the reflected light which the incident light which carried out incidence to liquid crystal cell 35b especially reflected by the reflector 47 is one of those which were set up as it was [P1] within the limits of 20 degrees from a normal Since the amount of reflected lights within the limits of 20 degrees increases [P1] from a normal to screen 1a of a liquid crystal display 3, distribution of a direction with the amount of reflected lights near an observer's view Ob1 also becomes high and the field where the amount of reflected lights is high moreover spreads at the time of reflective mode In the view of practical use, the include angle of the direction P1 of a normal and the main observation direction alpha 1 to make can realize the liquid crystal display of a bright display (screen) in 0 times thru/or 20 degrees especially.

[0050] In addition, in the reflective mold liquid crystal display 3 of the 3rd operation gestalt shown in drawing 5 , although the reflector 47 was formed as layer with the another electrode layer 15, if electrode layer 15 the very thing is formed by the reflector 47 and the electrode layer 15 is formed in the location of the reflector 47 of drawing 5 , a transparent electrode layer can serve as a reflector and the lamination of a reflective mold liquid crystal display will be simplified. Moreover, in the 3rd operation gestalt, although the case of the attachment type in a reflector which contained the reflector 47 in which the light which carried out incidence from the outside is reflected between the substrate 10 and the substrate 20 was explained, it can also consider as the reflector external type which prepared the

reflector in the outside of two substrates which pinched the liquid crystal layer. Moreover, although the case where the liquid crystal display of this invention was applied to a reflective mold liquid crystal display was explained in the 3rd operation gestalt Are applicable also to a transflective reflective mold liquid crystal display. The thickness of a reflector 47 in that case The range of 8nm - 50nm (80A - 500A), desirable -- the range of 8nm - 30nm (80A - 300A) -- what is necessary is to make it still more preferably the range of 8nm - 20nm (80A - 200A), and just to equip the external surface side of the 1st substrate 10 with a back light

[0051] Although the 3rd operation gestalt explained the case where this invention was applied to the reflective mold liquid crystal display of a simple matrix type, it is applicable like the liquid crystal display of a thin film transistor, the active-matrix mold using a thin-film diode, or a segmental die etc. Each of these liquid crystal displays is contained in this invention. in addition, the 1- in the 3rd operation gestalt, although the case where one phase contrast plate was formed between the 2nd substrate 20 and a polarizing plate 28 was explained, two or more phase contrast plates may be formed.

[0052] Drawing 11 to screen 1a of the reflective mold liquid crystal display 3 of the 3rd operation gestalt Outdoor daylight is irradiated at 30 degrees (include angle with the optical axis of the outdoor daylight illuminated from the opposite side of the view Ob1 of the observer who observes a display from one perpendicular (normal) side stood to screen 1a to make) of incident angles. The relation between the light-receiving angle (degree) when shaking the observation direction alpha (light-receiving angle) from a perpendicular location (normal location) (0 degree) to 60 degrees and brightness (reflection factor) is shown. Continuous-line **, **, and alternate long and short dash line ** show the relation between the light-receiving angle of the reflective mold liquid crystal display of the 3rd operation gestalt, and a reflection factor among drawing 11 , and the difference in the thing of continuous-line **, **, and alternate long and short dash line ** is the point that a configuration, the array direction, etc. of a crevice 63 of a reflector 47 differ from each other. At drawing 11 , broken-line ** showed the relation between the light-receiving angle of the thing of a type which has not prepared the back light with the liquid crystal display shown in drawing 12 or drawing 13 used from the former as an example of a comparison, and a reflection factor.

[0053] It is thought that the display seen from other directions although the display seen from specular reflection since the reflection factor is sharply and small, if the peak of a reflection factor is in the include angle (30 degrees of light-receiving angles) of specular reflection in the liquid crystal display of the example of a comparison so that clearly from drawing 11 , and it becomes small [20 degrees of light-receiving angles] looked bright looks dark. On the other hand, in the liquid crystal display 3 of the 3rd operation gestalt which has the property shown by continuous-line **, there is a peak of a reflection factor within limits smaller than 30 degrees from (0 degree of light-receiving angles) a normal. The peak field where especially a reflection factor is high exists focusing on about 25 degrees of carrier optic angles, the high reflection factor is shown compared with the example of a comparison in 0 degree - 30 degrees of light-receiving angles, and when a display is observed from the direction near the direction of a normal, it is thought that a display looks bright from the thing of the example of a comparison. Moreover, in the liquid crystal display 3 of the 3rd operation gestalt which has the property shown by continuous-line **, the peak of a reflection factor is within the limits of 20 degrees from a normal (0 degree of light-receiving angles). The peak field where especially a reflection factor is high exists focusing on about 15 degrees of carrier optic angles, the high reflection factor is shown compared with the example of a comparison in 0 degree - 22 degrees of light-receiving angles, and when a display is observed from the direction near the direction of a normal, it is thought that a display looks bright from the thing of the example of a comparison. Moreover, in the liquid crystal display 3 of the 3rd operation gestalt which has the property shown by alternate long and short dash line **, the peak of a reflection factor is within the limits of about 20 degrees from a normal (0 degree of light-receiving angles). The reflection factor near about 20 degrees of carrier optic angles is higher than the reflection factor of the include angle of specular reflection, the high reflection factor is shown compared with the example of a

comparison in 0 degree - 25 degrees of light-receiving angles, and when a display is observed from the direction near the direction of a normal, it is thought that a display looks bright from the thing of the example of a comparison. Moreover, it sets to the liquid crystal display 3 of the 3rd operation gestalt which has the property shown by continuous-line **, **, or alternate long and short dash line **. It has the reflection property which serves as unsymmetrical reflection factor distribution to the specular reflection include angle of incident light. And the maximum of a reflection factor is equipped with the reflection property which is in the range (light-receiving include-angle range) whenever [smaller than specular reflection include angle (30 degrees of light-receiving angles / This operation gestalt /) of incident light angle-of-reflection]. Moreover, although the profile of the graph which shows reflection factor distribution is stair-like, the maximum of a reflection factor is near 20 degrees of light-receiving angles and this maximum exists in the crowning of the stairway profile of the above in the liquid crystal display 3 of the 3rd operation gestalt which has the property especially shown by alternate long and short dash line ** In the thing of the example of a comparison, it has the reflection property which serves as reflection factor distribution of the symmetry to the specular reflection include angle of incident light. For this reason, especially visibility will become good if the liquid crystal display of this operation gestalt is built into the liquid crystal display of this operation gestalt of one of the above-mentioned configurations at the display of pocket electronic equipment, such as a cellular phone and note type PC.

[0054] (4th operation gestalt) Drawing 15 is drawing having shown typically the partial cross-section structure of the reflective mold liquid crystal display which is the 4th operation gestalt of this invention. The place where the reflective mold liquid crystal display 4 of drawing 15 differs from the reflective mold liquid crystal display 3 shown in drawing 5 is the point that the configurations of the reflector prepared in liquid crystal cell 35b differ. Crevices 163a, 163b, and 163c and -- (generally a crevice 163 is called) which have many light reflex nature adjoin mutually irregularly the front face (datum level) of the plate-like base material 61 which consists of aluminum, and the reflector 47 with which the reflective mold liquid crystal display 4 of this operation gestalt was equipped is formed in it.

[0055] An inside configuration [in / as shown in drawing 16 / for a sectional view / in these crevices 163 / the specific longitudinal section Y of a crevice 163] It consists of the 3rd curve or straight line L from the vertex D of a crevice to other peripheries S2 succeeding the 2nd curve K which results in the 3rd curve or a straight line L, and this 2nd curve K succeeding the 1st curve J from the periphery S1 of 1 of a crevice to Vertex D, and this 1st curve J. In Vertex D, the tilt angle to the base material front face S became zero, and both these [1st] and the 2nd curve are connected mutually.

[0056] The tilt angle to the base material front face S of the 1st curve J is more sudden than the tilt angle, the 3rd curve, or straight line L of the 2nd curve K, and Vertex D is located in the location [core / O / of a crevice 3] shifted in the direction of Y. That is, the average (henceforth the average of the tilt angle of the 1st curve J) of the absolute value of the tilt angle to the base material front face S of the 1st curve J is made larger than the average of the average of the absolute value of the tilt angle to the base material front face S of the 2nd curve K, and the absolute value of the tilt angle to the base material front face S of the 3rd curve or a straight line L. Moreover, the average of the absolute value of the tilt angle to the base material front face S of the 2nd curve K (It is hereafter called the average of the tilt angle of the 2nd curve K.) It differs from the average (average of the tilt angle of the following, the 3rd curve, or a straight line L) of the absolute value of the tilt angle to the base material front face S of the 3rd curve or a straight line L, and the direction of the average of the tilt angle of the 3rd curve or a straight line L is made larger than the average of the tilt angle of the 2nd curve K with this operation gestalt.

[0057] In other words, magnitude of the radius of curvature R1 of the 1st curve J is made smaller than the radius of curvature R2 of the 2nd curve K, and the radius of curvature R3 of the 3rd curve or a straight line L, and magnitude of the radius of curvature R3 of the 3rd curve or a straight line L is made smaller than the radius of curvature R2 of the 2nd curve K. In addition, the 3rd curve of the above or a

straight line L turns into a straight line, when radius of curvature R3 is infinity.
[0058] The average of the tilt angle to Crevices 163a, 163b, and 163c and the base material front face S of the 1st curve J in -- differs in 1 degree - 89 degrees irregularly. Moreover, the average of the tilt angle to Crevices 163a, 163b, and 163c and the base material front face S of the 2nd curve K in -- differs in 0.5 degrees - 88 degrees irregularly. Moreover, the average of the tilt angle to the base material front face S of Crevices 163a, 163b, and 163c, the 3rd curve in --, or a straight line L differs in 0.5 degrees - 88 degrees irregularly.
[0059] Since each tilt angle of the 1st curve, the 2nd curve, the 3rd curve, or a straight line is changing gently-sloping, maximum-angle-of-inclination deltamax (absolute value) of the 1st curve J is larger than maximum-angle-of-inclination (absolute value) deltab of the 2nd curve K, and maximum-angle-of-inclination (absolute value) deltac of the 3rd curve or a straight line L. Moreover, the tilt angle to the base material front face of the vertex D where the 1st curve J and the 2nd curve K touch serves as zero, the 1st curve J whose tilt angle is a negative value, and the 2nd curve K whose tilt angle is a forward value are continuing gently-sloping, and the 2nd curve K, the 3rd curve, or straight line L whose tilt angle is a forward value is continuing gently-sloping. In the reflector of this operation gestalt, each maximum-angle-of-inclination deltamax in Crevices 163a, 163b, and 163c and -- differs within the limits of 2-90 degrees irregularly. However, many crevices differ in within the limits whose maximum-angle-of-inclination deltamax is 4 degrees - 35 degrees irregularly.
[0060] Moreover, this crevice 163 has the minimum point (point on the curved surface where a tilt angle serves as zero) D that that concave surface is single. And this minimum point D and the distance on the front face S of a base material of a base material form depth d of a crevice 163, and this depth d differs within the limits of 0.1 micrometers - 3 micrometers irregularly about Crevices 163a, 163b, and 163c and --, respectively. Moreover, Crevices 163a, 163b, and 163c are irregularly arranged by within the limits whose pitch of an adjoining crevice is 5 micrometers - 50 micrometers.
[0061] In this operation gestalt, Crevices 163a, 163b, and 163c and each specific longitudinal section Y in -- are each in the same direction. Moreover, it is formed so that each 1st curve J may gather in the direction of the direction Y distant from an observer's view Ob1. Moreover, it is formed so that each 2nd curve K, the 3rd curve, and a straight line L may be equal to the direction and opposite direction of the direction Y distant from a view Ob1 of an observer.
[0062] In the reflector 147 of this operation gestalt, it is formed so that each 1st curve J may carry out orientation in the single direction, and moreover, since the average of the tilt angle of the 1st curve J is made larger than the average of the tilt angle to the base material front face S of the 2nd curve K, and the average of the tilt angle to the base material front face S of the 3rd curve or a straight line L and is, the reflection property is the thing [direction / of the specular reflection over the base material front face S] shifted. That is, the reflected light to the incident light from the slanting upper part of the direction of Y is what the bright display rectangle shifted in the direction shifted in the direction of a normal over the base material front face S from the direction of specular reflection. Furthermore, in the reflector 147 of this operation gestalt, it is formed so that the 2nd curve K, the 3rd curve, or a straight line L may carry out orientation to the 1st curve J and an opposite direction respectively. Since the direction of the average of the tilt angle of the 3rd curve or a straight line L is furthermore made larger than the average of the tilt angle of the 2nd curve K, as a synthetic reflection property in the specific longitudinal section Y The reflection factor of the direction reflected by the field of the 2nd curvilinear K circumference increases, and the reflection factor of the direction further reflected by the field of the 3rd curve or straight-line L circumference rather than the magnitude of this reflection factor becomes what became large. Therefore, it can consider as the reflection property which centralized the reflected light in the specific direction moderately.
[0063] Drawing 17 to screen 1a of the reflective mold liquid crystal display 4 of the 4th operation gestalt Outdoor daylight is irradiated at 30 degrees (include angle with the optical axis of the outdoor daylight illuminated from the opposite side of the view Ob1 of the observer who observes a display from one

perpendicular (normal) side stood to screen 1a to make) of incident angles. The relation between the light-receiving angle (degree) when shaking the observation direction alpha (light-receiving angle) from a perpendicular location (normal location) (0 degree) to 60 degrees and brightness (reflection factor) is shown. Alternate long and short dash line ** shows the relation between the light-receiving angle of the reflective mold liquid crystal display of the 4th operation gestalt, and a reflection factor among drawing 17 . In drawing 17 , broken-line ** shows the relation between the light-receiving angle of the thing of a type which has not prepared the back light with the liquid crystal display shown in drawing 1212 or drawing 13 used from the former as an example of a comparison, and a reflection factor, and since the reflection property of the liquid crystal display of this example of a comparison is as having explained using drawing 3 or drawing 11 , it omits explanation.

[0064] The profile of the graph which shows reflection factor distribution with the liquid crystal display 4 of the 4th operation gestalt which has the property shown by alternate long and short dash line ** is stair-like. And it has the reflection property which becomes unsymmetrical to the specular reflection include angle of incident light. Moreover, the maximum of a reflection factor exists near [smaller than the specular reflection include angle (30 degrees of light-receiving angles / This operation gestalt /) of incident light] 20 degrees of light-receiving angles located in the range (light-receiving include-angle range) whenever [angle-of-reflection]. The maximum of a reflection factor is equipped with the reflection property which exists in the crowning of the stairway profile of the above, and, moreover, a value with the bigger maximum of a reflection factor than the liquid crystal display of the 3rd operation gestalt is acquired. Moreover, with the liquid crystal display 4 of this 4th operation gestalt, the reflection factor near about 20 degrees of carrier optic angles is higher than the reflection factor of the include angle of specular reflection, the high reflection factor is shown compared with the example of a comparison in 0 degree - 25 degrees of light-receiving angles, and when a display is observed from the direction near the direction of a normal, with it, it is thought that a display looks bright from the thing of the example of a comparison.

[0065] (5th operation gestalt) Next, the reflective mold liquid crystal display which is the 5th operation gestalt of this invention is explained. The place where the reflective mold liquid crystal display of the 5th operation gestalt differs from the reflective mold liquid crystal display 4 of the 4th operation gestalt shown in drawing 15 is the point that the configurations of the reflector prepared in a liquid crystal cell differ. The configurations of the crevice formed in the front face (datum level) of the plate-like base material 61 are just going to differ the place where the reflector with which the reflective mold liquid crystal display of the gestalt of this operation was equipped differs from the reflector with which the reflective mold liquid crystal display of the 4th operation gestalt was equipped. Drawing 18 is the explanatory view of the crevice 263 of the reflector 247 with which the reflective mold liquid crystal display of the gestalt of this operation was equipped, drawing 18 R> 8 (a) is the sectional view of a crevice 263, and drawing 18 (b) is the top view of a crevice 263.

[0066] As shown in drawing 18 , the inside of each crevice 263 is looked like [the location surrounded by periphery curved-surface 264a and periphery curved-surface 264a], and is formed from certain bottom curved-surface 4b. Periphery curved-surface 264a sets a core to O1, and is a part of spherical surface whose radius is R4. Moreover, bottom curved-surface 264b sets a core to O2, and is a part of spherical surface whose radius is R5. From O1 and O2 which are the core of each spherical surface, the normal stood to the front face of a reflector is respectively located on the separate straight line L1 and L2. Moreover, each specific longitudinal section Y in crevice 263 -- is each in the same direction. Moreover, it is formed so that each bottom curved-surface 264b may gather in the near direction (the direction of Direction Y and an opposite direction distant from an observer's view Ob1, i.e., the left lateral of drawing 18) from an observer's view Ob1. The direction of the right of drawing 18 is the incidence side of light.

[0067] Each radii R1 and R2 have the relation of R1<R2, and it changes in the range of 1<=70 micrometers of 5 micrometer<=R, and 2<=100 micrometers of 10 micrometer<=R. Moreover, in drawing 2

(a), theta 4 is the tilt angle of periphery curved-surface 264a, and changes in 4 degree<=theta4 <=35 degree and -35 degree<=theta4 <=-4 degree. Moreover, theta 5 is the tilt angle of bottom curved-surface 264b, and changes in -17 degree<=theta5 <=17 degree. In addition, the radius r4 of seen periphery curved-surface 264a and the radius r5 of bottom curved-surface 264b are decided according to each radius, R4 and R5, and the tilt angles theta4 and theta5 from a flat surface.

[0068] Depth d of a crevice 263 takes a random value for every crevice 0.1 thru/or in 3 micrometers. It is because specular reflection will become strong too much if the depth of a crevice 263 does not fulfill 0.1 micrometers. The pitch of the adjoining crevice 263 is arranged at random in 2 micrometers thru/or 50 micrometers. It is because there is fault that the interference color of light will come out and the reflected light will color when regularity is in the pitch of the crevice 263 which adjoins temporarily. Moreover, when the pitch of the adjoining crevice 263 is less than 2 micrometers, there is constraint on manufacture of the crevice of a reflector and floor to floor time becomes very long.

[0069] As a result of measuring the relation between the light-receiving angle of the reflective mold liquid crystal display of the 5th operation gestalt, and a reflection factor like the approach performed with the operation gestalt of the above 3rd, the relation between the light-receiving angle of the reflective mold liquid crystal display of the 5th operation gestalt and a reflection factor is equipped with the property shown by alternate long and short dash line ** of drawing 11 , and the same property. Thus, in the reflective mold liquid crystal display of this operation gestalt with which it had the reflector 247, since periphery curved-surface 264a which becomes the inside of a crevice 263 from a part of spherical surface with a small radius exists and the range of a tilt angle with a comparatively large absolute value is given, it has the good reflection factor in the range whenever [of about 15 degrees - 45 degrees of carrier optic angles / large angle-of-reflection]. Moreover, since bottom curved-surface 264b which consists of a part of spherical surface with a large radius, i.e., the curved surface near a flat side, is unevenly distributed, the rate of an inside of giving the tilt angle of the specific range becomes high. Consequently, the reflection factor of whenever [smaller than specular reflection include angle (this operation gestalt 30 light-receiving angles) angle-of-reflection] becomes the highest, and the nearby reflection factor is also high with a peak of the direction. In addition, when incidence is carried out from the direction of the left of drawing 18 , 30 degrees which is whenever [incident angle], and whenever [angle-of-reflection / of an object direction], rather than 30 degrees, the reflection factor of whenever [large angle-of-reflection] becomes the highest, and a nearby reflection factor also becomes high with a peak of the direction.

[0070]

[Effect of the Invention] As mentioned above, as explained to the detail, when the include angles of the direction of a normal over the screen of a liquid crystal display and the main observation direction to make are 0 times thru/or 20 degrees according to the liquid crystal display of this invention By having set up the peak of the reflection factor of the reflected light which the incident light which carried out incidence to said liquid crystal display reflected by said reflector so that it might result [from / said / a normal] within the limits of 30 degrees, preferably By having set up the peak of the reflection factor of the reflected light which the incident light which carried out incidence to said liquid crystal display reflected by said reflector so that it might result [from / said / a normal] within the limits of 20 degrees When a display is observed from the direction near the direction of a normal over the screen of a liquid crystal display, it can have a viewing-angle property which looks brighter than other viewing angles. Moreover, when the include angles of the direction of a normal over the screen of a liquid crystal display and the main observation direction to make are 0 times thru/or 20 degrees according to the liquid crystal display of this invention By having been set up as the peak of the reflection factor of the reflected light which the incident light which carried out incidence to said liquid crystal display reflected by said reflector was in the range smaller than 30 degrees from [said] a normal, preferably By having set up the peak of the reflection factor of the reflected light which the incident light which carried out incidence to said liquid crystal display reflected by said reflector, as it was [said] in the range of 20

degrees from a normal When a display is observed from the direction near the direction of a normal over the screen of a liquid crystal display, it can have a viewing-angle property which looks brighter than other viewing angles. Moreover, according to the pocket electronic equipment of this invention, pocket electronic equipment which was excellent in the visibility of the screen (screen) also in actuation in reflective mode or actuation [which / of reflective mode and the transparent mode], such as a cellular phone and note type PC, is obtained by having equipped the display with the liquid crystal display of this invention of one of the above-mentioned configurations.

[Translation done.]

DESCRIPTION OF DRAWINGS

[Brief Description of the Drawings]
[Drawing 1] Drawing showing the partial cross-section structure of the transflective reflective mold liquid crystal display of the 1st operation gestalt of this invention.
[Drawing 2] The perspective view having expanded and shown the reflector which consists of organic film with which the liquid crystal display of drawing 1 was equipped, and metallic reflection film.
[Drawing 3] The graph which shows the relation between the light-receiving angle of the liquid crystal display of the 1st operation gestalt, and the liquid crystal display of the example of a comparison, and a reflection factor.
[Drawing 4] Drawing showing the partial cross-section structure of the transflective reflective mold liquid crystal display of the 2nd operation gestalt of this invention.
[Drawing 5] Drawing showing the partial cross-section structure of the reflective mold liquid crystal display of the 3rd operation gestalt of this invention.
[Drawing 6] The perspective view having expanded and shown the reflector with which the liquid crystal display of drawing 5 was equipped.
[Drawing 7] The perspective view showing forming [in the front face of the reflector of drawing 6] 1 crevice.
[Drawing 8] The sectional view showing the crevice of drawing 7 .
[Drawing 9] The sectional view showing the part of the reflector of drawing 6 .
[Drawing 10] The sectional view showing one crevice of the reflector of drawing 6 .
[Drawing 11] The graph which shows the relation between the light-receiving angle of the liquid crystal display of the 3rd operation gestalt, and the liquid crystal display of the example of a comparison, and a reflection factor.
[Drawing 12] The sectional view showing the outline configuration of the conventional transflective reflective mold liquid crystal display.
[Drawing 13] The sectional view showing the example of others of the conventional transflective reflective mold liquid crystal display.

[Drawing 14] The explanatory view of the busy condition of the transflective reflective mold liquid crystal display with which the cellular phone was equipped.
[Drawing 15] Drawing showing the partial cross-section structure of the reflective mold liquid crystal display of the 4th operation gestalt of this invention.
[Drawing 16] The sectional view showing the crevice formed in the front face of the reflector with which the reflective mold liquid crystal display of drawing 15 was equipped.
[Drawing 17] The graph which shows the relation between the light-receiving angle of the liquid crystal display of the 4th operation gestalt, and the liquid crystal display of the example of a comparison, and a reflection factor.
[Drawing 18] The explanatory view of the crevice of the reflector with which the reflective mold liquid crystal display of this 5th operation gestalt of this invention was equipped.
[Description of Notations]
1, 2, 3, 4 Liquid crystal display
1a Screen
5 Back Light
7 47,147,247 Reflector
10 Substrate (One Substrate)
11 Organic Film (Base Material)
12 Metallic Reflection Film (Metal Membrane)
12A, 63, 63a, 63b, 63c, 163, 263 Crevice
13 Color Filter
14 24 Overcoat film
15 25 Transparent electrode layer (electrode)
16 26 Orientation film
18 28 Polarizing plate
20 Substrate (Substrate of Another Side)
27 Phase Contrast Plate
30 Liquid Crystal Layer
35, 35a, 35b Liquid crystal cell
40 Sealant
53 Transparence Mediation Layer
61 Base Material
264a Periphery curved surface
264b Bottom curved surface
P1 The direction of a normal
Ob1 View
theta 1 Include angle
alpha 1 The observation direction

[Translation done.]

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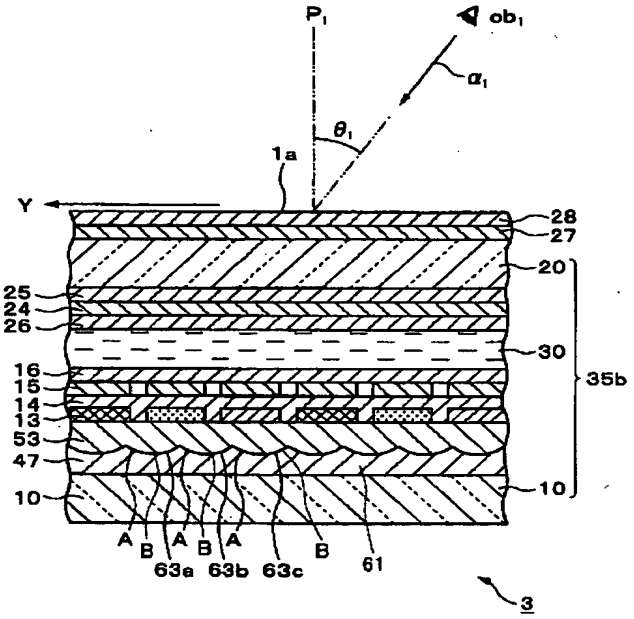
最終頁に続く

(54)【発明の名称】　液晶表示装置および携帯電子機器

(57)【要約】
【課題】　液晶表示装置の表示面に対する法線方向に近い方向から表示を観察したとき、他の視角より明るく見えるような特性を有する液晶表示装置の提供。
【解決手段】　液晶層３０を挟んで対向する基板１０、２０の一方の基板１０の内面側に電極および配向膜を該一方の基板側１０から順に設け、他方の基板２０の内面側に電極および配向膜を他方の基板２０側から順に設けた液晶セル３５ｂの基板１０の外面側または基板１０とこれの内面側に設けられた電極１５の間に反射体４７を設け、基板２０の外面側に位相差板２７および偏光板２８を基板２０側から順に設けてなり、該液晶表示装置３の表示面１ａに対する法線方向P_1と主たる観察方向αとのなす角度が０度乃至２０度のときに、液晶表示装置３に入射した入射光が反射体４７で反射した反射光の反射率のピークが、法線方向P_1から２０度の範囲内にあるように設定された液晶表示装置３。



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【特許請求の範囲】

【請求項１】　液晶層を挟んで対向する基板の一方の基板の内面側に電極および配向膜を該一方の基板側から順に設け、他方の基板の内面側に電極および配向膜を該他方の基板側から順に設けた液晶セルの前記一方の基板の外面側または前記一方の基板とこれの内面側に設けられた電極の間に反射体を設け、前記他方の基板の外面側に位相差板および偏光板を前記他方の基板側から順に設けてなり、

該液晶表示装置の表示面に対する法線方向と主たる観察方向とのなす角度が０度乃至２０度のときに、前記液晶表示装置に入射した入射光が前記反射体で反射した反射光の反射率は、正反射角度を中心に反射率が高いピーク領域を有し、かつこの反射率のピークは前記法線方向から３０度の範囲内まで至るように設定されたことを特徴とする液晶表示装置。

【請求項２】　前記液晶表示装置に入射した入射光が前記反射体で反射した反射光の反射率のピークが、前記法線方向から２０度の範囲内まで至るように設定されたことを特徴とする請求項１記載の液晶表示装置。

【請求項３】　前記反射体は、基材上に形成した金属膜または基材の表面に光反射性を有する複数の凹部が形成され、これら凹部はそれぞれ凹部の内面が球面の一部をなし、かつ傾斜角分布が－３０度～＋３０度の範囲に形成され、前記凹部の深さが０．１μｍ～３μｍの範囲内で不規則に形成され、前記複数の凹部は隣接する凹部のピッチが２μｍ～５０μｍの範囲内で不規則に配置されたことを特徴とする請求項１又は２記載の液晶表示装置。

【請求項４】　液晶層を挟んで対向する基板の一方の基板の内面側に電極および配向膜を該一方の基板側から順に設け、他方の基板の内面側に電極および配向膜を該他方の基板側から順に設けた液晶セルの前記一方の基板の外面側または前記一方の基板とこれの内面側に設けられた電極の間に反射体を設け、前記他方の基板の外面側に位相差板および偏光板を前記他方の基板側から順に設けてなり、

該液晶表示装置の表示面に対する法線方向と主たる観察方向とのなす角度が０度乃至２０度のときに、前記液晶表示装置に入射した入射光が前記反射体で反射した反射光の反射率のピークが、前記法線方向から３０度より小さい範囲内にあるように設定されたことを特徴とする液晶表示装置。

【請求項５】　前記液晶表示装置に入射した入射光が前記反射体で反射した反射光の反射率のピークが、前記法線方向から２０度の範囲内にあるように設定されたことを特徴とする請求項４記載の液晶表示装置。

【請求項６】　前記反射体は、基材上に形成した金属膜または基材の表面に光反射性を有する複数の凹部が形成され、これらの凹部はそれぞれ、凹部の１側部で傾斜角

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（曲面上の任意の点における接平面と基材表面とのなす角度の絶対値）が最大となるように形成され、前記凹部の深さが０．１μｍ～３μｍの範囲内で不規則に形成され、前記複数の凹部は隣接する凹部のピッチが２μｍ～５０μｍの範囲内で不規則に配置されたことを特徴とする請求項４又は５に記載の液晶表示装置。

【請求項７】　前記反射体は、基材上に形成した金属膜または基材の表面に光反射性を有する複数の凹部が形成され、これらの凹部は、各々が凹部の最深点を通過する以下の特定縦断面を有し、前記特定縦断面は、その内面の形状が、凹部の一の周辺部から最深点に至る第１曲線と、この第１曲線に連続して、凹部の最深点から第３曲線又は直線に至る第２曲線と、この第２曲線に連続して、他の周辺部に至る第３曲線又は直線とからなり、前記第１曲線の基材表面に対する傾斜角の絶対値の平均値が、第２曲線の基材表面に対する傾斜角の絶対値の平均値より大きくされ、しかも第３の曲線又は直線の基材表面に対する傾斜角の絶対値の平均値より大きくされ、しかも第２曲線の基材表面に対する傾斜角の絶対値の平均値と第３の曲線又は直線の基材表面に対する傾斜角の絶対値の平均値とは異なることを特徴とする請求項４又は５に記載の液晶表示装置。

【請求項８】　前記反射体は、基材上に形成した金属膜または基材の表面に光反射性を有する複数の凹部が形成され、前記凹部の内面が、各々半径の異なる２つの球面の一部である周縁曲面と周縁曲面に囲まれた位置に存在する底曲面とを連続させた面からなり、周縁曲面を形成する球面の半径が、底曲面を形成する球面の半径より小さいと共に、各々の球面の中心から反射体表面に立てた法線が、互いに異なる直線上に存在することを特徴とする請求項４又は５に記載の液晶表示装置。

【請求項９】　前記反射体は入射光の正反射角度に対して非対称の反射率分布を有し、しかも反射率の最大値は入射光の正反射角度より小さい受光角度範囲にある反射特性を備えることを特徴とする請求項４乃至８のいずれか一項に記載の液晶表示装置。

【請求項１０】　前記反射体の反射率分布を示すグラフのプロファイルが階段状であり、前記反射率の最大値は前記階段状のプロファイルの頂部に存在することを特徴とする請求項９に記載の液晶表示装置。

【請求項１１】　前記反射体の基材又は金属膜の厚みが８ｎｍ～２０ｎｍであることを特徴とする請求項１乃至１０のいずれか一項に記載の液晶表示装置。

【請求項１２】　請求項１乃至１１のいずれか一項に記載の液晶表示装置が表示部に備えられたことを特徴とする携帯電子機器。

【発明の詳細な説明】

【０００１】

【発明の属する技術分野】本発明は、反射体を備えた液晶表示装置及び携帯電子機器に係わり、液晶表示装置の

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表示面に対する法線方向に近い方向から表示を観察したとき、他の視角より明るく見えるような視角特性を有する液晶表示装置及びこのような特性を備えた液晶表示装置を表示部に備えた携帯電子機器に関する。

【０００２】

【従来の技術】一般に、液晶表示装置の表示形態には、バックライトを備えた半透過型、透過型と呼ばれるものと、反射型と呼ばれるものがある。反射型液晶表示装置は、太陽光、照明光等の外光だけを利用してバックライト無しで表示する液晶表示装置であり、例えば薄型で、軽量化、低消費電力が要求される携帯情報端末等に多く用いられている。また、半透過型液晶表示装置は、外光が十分得られない環境においてはバックライトを点灯させて透過モードで動作し、外光が十分得られる場合にはバックライトを点灯させない反射モードで動作するものであり、携帯電話やノート型パーソナルコンピュータ（ノート型ＰＣ）等の携帯電子機器に多く用いられている。

【０００３】図１２は、従来の半透過反射型液晶表示装置の例を示す断面図である。この半透過反射型液晶表示装置は、下側偏光板７０と下側位相差板７３ａ付きの反射板７１の下側位相差板７３ａ上に、反射モードＳＴＮ（Super-Twisted Nematic）方式用の液晶セル７２、前方散乱板９０、上側位相差板７３ｂ、上側偏光板７４が下側位相差板７３ｂ側から順に積層され、一方、反射板７１の下面側に光源としてバックライト９５が備えられた概略構成となっている。液晶セル７２は、下側ガラス基板７５、カラーフィルタ７６、下側透明電極層７８、下側配向膜７９、この下側配向膜７９と隙間を隔てて対向配置された上側配向膜８０、上側透明電極層８１、上側ガラス基板８２が下側偏光板７０側から順に積層され、上記下側及び上側の配向膜７９，８０間にＳＴＮ液晶層８３が配設された概略構成となっている。カラーフィルタ７６と下側透明電極層７８との間には、シリカやアクリル樹脂からなるオーバーコート層（図示略）が設けられている。

【０００４】反射板７１は、表面が鏡面状態のＡｌ膜から構成されており、バックライト９０を使用時にバックライト光を透過するための孔７１ａが形成されている。位相差板７３ａ、７３ｂは、ＳＴＮ液晶を透過する光の位相差を補償することにより表示が青や黄色に着色するのを防止するためのものである。前方散乱板９０は、上側偏光板７４、上側位相差板７３ｂを通って入射してきた入射光（外光）を液晶セル７２側に散乱させることにより、入射光が反射板７１表面で反射した反射光が正反射の方向だけでなく、正反射の近傍の方向にも反射するようにするために設けられたものである。

【０００５】また、従来の半透過反射型液晶表示装置の例としては図１３に示すものがある。この反射型液晶表示装置は、反射モードＳＴＮ（Super-Twisted Nemati

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c）方式用の液晶セル１７２上に 第１の位相差板１７３ａ、第２の位相差板１７３ｂ、偏光板１７４が上側ガラス基板１８２側から順に積層され、一方、液晶セル１７２の下面側に光源としてバックライト１９５が備えられた概略構成となっている。液晶セル１７２は、下側ガラス基板１７５、反射体１７１、オーバーコート層１７１ｃ、カラーフィルタ１７６、オーバーコート層１７７ａ、下側透明電極層１７８、下側配向膜１７９、この下側配向膜１７９と隙間を隔てて対向配置された上側配向膜１８０、トップコート層１７７ｂ、上側透明電極層１８１、上側ガラス基板１８２が順に積層された概略構成となっている。

【０００６】反射体１７１は、反射面に多数の微細な凹凸（図１３では凹部１７１ｅ･･･）が不規則に隣接して形成されているものである。上記凹凸の形成方法としては、例えば感光性樹脂層等からなる樹脂基材１７１ａの表面にマスクパターンを通して光を照射し、現像処理によって隣接する多数の微細な球面状凹部を形成し、このような球面状凹部が多数形成された樹脂基材１７１ａの表面にアルミニウムや銀などを蒸着またはメッキし、凹凸（凹部１７１ｅ･･･）を有する金属膜１７１ｂを形成する方法などが知られている。金属膜１７１ｂの厚みは、３０ｎｍ程度まで薄くすることにより、透過モード時にバックライト１９５からの光を透過できるようにされている。上記凹部１７１･･･の形状は、内面が球面状で、傾斜角分布が－２０度～＋２０度の範囲で、深さが０．１μｍ～３μｍの範囲内とされ、その相互距離は隣接する凹部間のピッチ（中心間の距離）が５μｍ～５０μｍの範囲内でばらつくように設定されたものである。

【０００７】

【発明が解決しようとする課題】ところで、液晶表示装置の表示性能としては、通常、①解像度、②コントラスト、③画面の明るさ、④色の鮮やかさ、⑤視野角範囲が広い等の視認性、などが良好であることが要求される。また、携帯電話やノート型ＰＣ等の携帯情報端末のように、表示面を斜めにして使用する装置に組み込まれた液晶表示装置は、図１４に示すように、一般的に表示面に対する法線方向に近い方向、具体的には法線方向Ｐから１０度の範囲内の方向から見られる場合が多い。また、一般的に観察者（使用者）が表示面（画面）を見るときの主たる観察方向αと法線方向Ｐとのなす角度θは０度乃至２０度の範囲が多い。図１４は、液晶表示装置からなる表示部１００が本体１０５に備えられた携帯電話を使用する状態の説明図である。図１４において、Ｐは表示部１００の表示面に対する法線、Ｑは入射光、ω_0は入射角度（例えば３０度）である。また、R_1は入射角度ω_0と反射角度ωが等しいときの反射光（正反射）、R_2は反射角度ωが入射角度ω_0より小さい反射光、R_3は反射角度ωが入射角度ω_0より大きい反射光である。

【０００８】図からも理解できるように、観察者の視点

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Ｏｂは通常法線方向Ｐに近い反射光$Ｒ_2$の方向、より具体的には法線方向Ｐから１０度までの範囲内の方向に集中する。これに対して反射光$Ｒ_1$、$Ｒ_3$は、表示面を下から見上げるような方向となり見づらいものである。従って、観察者の利用の便宜を考えると、広い視野角を確保すると同時に、正反射より反射角度の小さい方向の反射率をより高くすることが望まれる。しかしながら図１２に示した従来の液晶表示装置においては、反射モード時は前方散乱板を設けていないタイプの液晶表示装置に比べて、入射光が反射する範囲が広くなるものの入射光の大部分は正反射およびその近傍の方向に反射する（反射率のピークは正反射の角度あるいは正反射の近傍の角度にある）ので、正反射およびその周辺の方向から見た表示は明るく見えるものの他の方向から見た表示は暗く見える。また、図１３に示した従来の液晶表示装置においても、入射光の大部分は正反射およびその近傍の方向に反射する（反射率のピークは正反射の角度あるいは正反射の近傍の両側の角度にある）ので、正反射およびその周辺の方向から見た表示は明るく見えるものの他の方向から見た表示は暗く見える。

【０００９】従って、従来の半透過反射型表示装置が表示部に備えられた携帯電話等の表示面を見ると、先に述べたように観察者の視点は通常法線方向Ｐに近い方向に集中するので、表示が暗く、一方、明るい表示を見ようとすると正反射およびその周辺の方向から表示を見なければならず、上記のように表示面を下から見上げるような方向となり見づらいものであった。

【００１０】本発明は、上記の課題を解決するためになされたものであって、液晶表示装置の表示面に対する法線方向に近い方向から表示を観察したとき、他の視角より明るく見えるような視角特性を有する液晶表示装置を提供することを目的の１つとする。また、本発明は、上記のような特性を有する液晶表示装置を表示部に備えた携帯電話、ノート型ＰＣ等の携帯電子端末等の携帯電子機器を提供することを目的の１つとする。

【００１１】

【課題を解決するための手段】上記の目的を達成するために、本発明の液晶表示装置は、液晶層を挟んで対向する基板の一方の基板の内面側に電極および配向膜を該一方の基板側から順に設け、他方の基板の内面側に電極および配向膜を該他方の基板側から順に設けた液晶セルの前記一方の基板の外面側または前記一方の基板とこれの内面側に設けられた電極の間に反射体を設け、前記他方の基板の外面側に位相差板および偏光板を前記他方の基板側から順に設けてなり、該液晶表示装置の表示面に対する法線方向と主たる観察方向とのなす角度が０度乃至２０度のときに、前記液晶表示装置に入射した入射光が前記反射体で反射した反射光の反射率は、正反射角度を中心に反射率が高いピーク領域を有し、かつこの反射率のピークは前記法線方向から３０度の範囲内まで至るように設定（反射率のピーク領域の一端が受光角０度から３０度の間に存在するように設定）されたことを特徴とするものである。かかる構成の本発明の液晶表示装置によれば、前記液晶表示装置の表示面に対する法線方向から３０度の範囲内までの範囲の反射光量が多くなるので、反射光量は観察者の視点に近い方向の分布も高くなり、実用の視点において、特に、前記法線方向と主たる観察方向とのなす角度が０度乃至２０度において、明るい表示（画面）の液晶表示装置を実現できる。

【００１２】上記の構成の本発明の液晶表示装置においては、前記液晶表示装置に入射した入射光が前記反射体で反射した反射光の反射率のピークが、前記法線方向から２０度の範囲内まで至るように設定（反射率のピーク領域の一端が受光角０度から２０度の間に存在するように設定）されていることが好ましい。かかる構成の本発明の液晶表示装置によれば、前記液晶表示装置の表示面に対する法線方向から２０度の範囲内までの範囲の反射光量が多くなり、反射光量は観察者の視点に近い方向の分布も高くなり、しかも反射光量が高い領域が広がるので、実用の視点において、特に、前記法線方向と主たる観察方向とのなす角度が０度乃至２０度において、明るい表示（画面）の液晶表示装置を実現できる。

【００１３】前記のような特性を備える液晶表示装置の実現手段の例としては、前記反射体として、基材上に形成した金属膜または基材の表面に光反射性を有する複数の凹部が形成され、これら凹部はそれぞれ凹部の内面が球面の一部をなし、かつ傾斜角分布が－３０度～＋３０度の範囲に形成され、前記凹部の深さが０．１μｍ～３μｍの範囲内で不規則に形成され、前記複数の凹部は隣接する凹部のピッチが２μｍ～５０μｍの範囲内で不規則に配置にされた構成のものを使用することにより実現できる。

【００１４】また、上記の目的を達成するために、本発明の液晶表示装置は、液晶層を挟んで対向する基板の一方の基板の内面側に電極および配向膜を該一方の基板側から順に設け、他方の基板の内面側に電極および配向膜を該他方の基板側から順に設けた液晶セルの前記一方の基板の外面側または前記一方の基板とこれの内面側に設けられた電極の間に反射体を設け、前記他方の基板の外面側に位相差板および偏光板を前記他方の基板側から順に設けてなり、該液晶表示装置の表示面に対する法線方向と主たる観察方向とのなす角度が０度乃至２０度のときに、前記液晶表示装置に入射した入射光が前記反射体で反射した反射光の反射率のピークが、前記法線方向から３０度より小さい範囲内にあるように設定されたことを特徴とする。かかる構成の本発明の液晶表示装置によれば、前記液晶表示装置の表示面に対する法線方向から３０度より小さい範囲内の反射光量が多くなるので、反射光量は観察者の視点に近い方向の分布が高くなり、実用の視点において、特に、前記法線方向と主たる観察方

向とのなす角度が０度乃至２０度において、明るい表示（画面）の液晶表示装置を実現できる。

【００１５】上記の構成の本発明の液晶表示装置においては、前記液晶表示装置に入射した入射光が前記反射体で反射した反射光の反射率のピークが、前記法線方向から２０度の範囲内にあるように設定されていることが好ましい。かかる構成の本発明の液晶表示装置によれば、前記液晶表示装置の表示面に対する法線方向から２０度の範囲内の反射光量が多くなり、反射光量は観察者の視点に近い方向の分布が高くなり、しかも反射光量が高い領域が広がるので、実用の視点において、特に、前記法線方向と主たる観察方向とのなす角度が０度乃至２０度において、明るい表示（画面）の液晶表示装置を実現できる。

【００１６】前記のような特性を備える液晶表示装置の実現手段の第一の例としては、前記反射体として、基材上に形成した金属膜または基材の表面に光反射性を有する複数の凹部が形成され、これらの凹部はそれぞれ、凹部の１側部で傾斜角（曲面上の任意の点における接平面と基材表面とのなす角度の絶対値）が最大となるように形成され、前記凹部の深さが０．１μｍ～３μｍの範囲内で不規則に形成され、前記複数の凹部は隣接する凹部のピッチが２μｍ～５０μｍの範囲内で不規則に配置された構成のものを使用することにより実現できる。前記のような特性を備える液晶表示装置の実現手段の第二の例としては、前記反射体として、基材上に形成した金属膜または基材の表面に光反射性を有する複数の凹部が形成され、これらの凹部は、各々が凹部の最深点を通過する以下の特定縦断面を有し、前記特定縦断面は、その内面の形状が、凹部の一の周辺部から最深点に至る第１曲線と、この第１曲線に連続して、凹部の最深点から第３曲線又は直線に至る第２曲線と、この第２曲線に連続して、他の周辺部に至る第３曲線又は直線とからなり、第１曲線の基材表面に対する傾斜角の絶対値の平均値が、第２曲線の基材表面に対する傾斜角の絶対値の平均値より大きくされ、しかも第３の曲線の基材表面に対する傾斜角の絶対値の平均値より大きくされ、しかも第２曲線の基材表面に対する傾斜角の絶対値の平均値と第３の曲線又は直線の基材表面に対する傾斜角の絶対値の平均値とは異なる構成にしたものを使用することにより実現できる。前記のような特性を備える液晶表示装置の実現手段の第三の例としては、前記反射体として、基材上に形成した金属膜または基材の表面に光反射性を有する複数の凹部が形成され、前記凹部の内面が、各々半径の異なる２つの球面の一部である周縁曲面と周縁曲面に囲まれた位置に存在する底曲面とを連続させた面からなり、周縁曲面を形成する球面の半径が、底曲面を形成する球面の半径より小さいと共に、各々の球面の中心から反射体表面に立てた法線が、互いに異なる直線上に存在する構成のものを使用することにより実現できる。

【００１７】また、前記のいずれかの構成の本発明の液晶表示装置においては、前記反射体は入射光の正反射角度に対して非対称の反射率分布を有し、しかも反射率の最大値は入射光の正反射角度より小さい反射角度範囲（受光角度範囲）にある反射特性を備えることを特徴とする。かかる構成の本発明の液晶表示装置によれば、正反射角度より小さい受光角度範囲の反射光量が多くなるので、反射光量は観察者の視点に近い方向の分布が高くなり、実用の視点において、明るい表示（画面）の液晶表示装置を実現できる。また、前記反射体の反射率分布を示すグラフのプロファイルが階段状であり、前記反射率の最大値は前記階段状のプロファイルの頂部に存在することが好ましい。このような反射率分布を示す反射体を備えた液晶表示装置によれば、正反射角度より小さい反射角度範囲（受光角度範囲）内の特定角度範囲の反射率がさらに高くなるので、反射光量は観察者の視点に近い方向の分布が高くなり、実用の視点において、明るい表示（画面）の液晶表示装置を実現できる。また、前記のいずれかの構成の本発明の液晶表示装置においては、前記反射体が、基材とこの上に形成した複数の凹部を有する金属膜からなる場合は、前記金属膜の厚みを８ｎｍ～２０ｎｍの範囲内とすることで、金属膜の厚みが薄くなり、前記反射体の下方側に設けたバックライトからの光の透光性を高めることができ、光を反射させる場合と、光を透過させる場合の両方において、優れた特性を発揮する半透過反射型液晶表示装置として使用できる。また、前記反射体が、複数の凹部を有する基材からなる場合は、前記基材の厚みを８ｎｍ～２０ｎｍの範囲内とすることで、基材の厚みが薄くなり、前記反射体の下方側に設けたバックライトからの光の透光性を高めることができ、光を反射させる場合と、光を透過させる場合の両方において、優れた特性を発揮する半透過反射型液晶表示装置として使用できる。

【００１８】上記の目的を達成するために、本発明の携帯電子機器は、上記のいずれかの構成の本発明の液晶表示装置が表示部に備えられたことを特徴とする。かかる構成の本発明の携帯電子機器によれば、反射モードの動作、あるいは反射モードと透過モードのいずれの動作においても表示面（画面）の視認性に優れた携帯電話やノート型ＰＣ等の携帯電子機器を得ることができる。

【００１９】

【発明の実施の形態】以下、本発明の実施の形態を図面を参照して説明するが、本発明は以下の実施の形態に限定されるものではない。

（第１の実施形態）図１は本発明の第１の実施形態である半透過反射型液晶表示装置の端部を含む部分断面構造を模式的に示した図である。図１において、本発明の半透過反射型液晶表示装置１は、液晶層３０を挟持して対向する透明なガラスなどからなる第１の基板（一方の基板）１０と、第２の基板（他方の基板）２０とをこれら

２枚の基板１０、２０の周縁部に環状に設けられたシール材４０で接着一体化した構成である。第１の基板１０の液晶層３０側には順に、反射体７と、カラー表示を行うためのカラーフィルタ１３と、反射体７を被覆して保護するとともに反射体７やカラーフィルタ１３による凹凸を平坦化するためのオーバーコート膜１４と、液晶層３０を駆動するための透明電極層１５と、液晶層３０を構成する液晶分子の配向を制御するための配向膜１６とが積層形成されている。また、第２の基板２０の液晶層３０側には順に、透明電極層２５、オーバーコート膜２４、配向膜２６が積層形成されている。

【００２０】上記の第１の基板１０と第２の基板２０と、これら基板間に設けられた各構成部材により、液晶セル３５が構成されている。第１の基板１０の液晶層３０側と反対側（第１の基板１０の外面側）に、偏光板１８が設けられており、第２の基板２０の液晶層３０側と反対側（第２の基板２０の外面側）には、位相差板２７と、偏光板２８がこの順で積層されている。偏光板２８の外側面は表示面１ａになっている。また、第１の基板１０の偏光板１８の外側には、半透過液晶表示装置１において透過表示を行うための光源としてのバックライト５が配設されている。

【００２１】また、この半透過反射型液晶表示装置１では、該液晶表示装置１の表示面１ａに対する法線方向P_1と主たる観察方向α_1とのなす角度θ_1が０度乃至２０度のときに、液晶セル３５に入射した入射光が反射体７で反射した反射光の反射率のピークが、法線方向P_1から３０度の範囲内まで至るように設定されており、好ましくは、上記反射光の反射率のピークが、法線方向P_1から２０度の範囲内まで至るように設定されている。

【００２２】上記反射体７は、有機膜（基材）１１と、この有機膜１１上に形成された金属反射膜（金属膜）１２から構成されている。有機膜１１は、その上に形成されている金属反射膜１２に凹凸形状を与えて反射光を効率よく散乱させるために設けられているものである。このように金属反射膜１２に凹凸形状を与えることにより、液晶表示装置１に入射した光を効率よく反射することができるため、反射モードにおける明るい表示を実現することができる。図２は有機膜１１と、その上に形成された金属反射膜１２を備えた反射体７を示す斜視図である。この図に示すように、有機膜１１の表面には、その内面が球面の一部をなす多数の凹部１２Ａが左右に重なり合うようにして連続して形成されており、その面上に金属反射膜１２が積層されている。

【００２３】上記凹部１２Ａの深さを０．１μｍ～３μｍの範囲でランダムに形成し、隣接する凹部１２Ａのピッチを２μｍ～５０μｍの範囲でランダムに配置し、上記凹部１２Ａ内面の傾斜角を－３０度～＋３０度の範囲に設定されている。特に、凹部１２Ａ内面の傾斜角分布を－３０度～＋３０度の範囲に設定する点、隣接する凹部１２Ａのピッチを平面全方向に対してランダムに配置する点が特に重要である。なぜならば、仮に隣接する凹部１２Ａのピッチに規則性があると、光の干渉色が出て反射光が色付いてしまうという不具合があるからである。また、凹部１２Ａ内面の傾斜角分布が－３０度～３０度の範囲を超えると、反射光の拡散角が広がりすぎて反射強度が低下し、明るい表示が得られない（反射光の拡散角が空気中で３６度以上になり、液晶表示装置内部の反射強度ピークが低下し、全反射ロスが大きくなるからである。）からである。この液晶表示装置１に設定される反射特性を変更（例えば、反射光の反射率のピークが法線方向P_1から３０度の範囲内まで至るようにする反射特性から、反射光の反射率のピークが法線方向P_1から２０度の範囲内まで至るようにする反射特性にする）するには、液晶表示装置１に備える反射体７として、例えば、凹部１２Ａ内面の傾斜角分布を異なるものに変更することにより可能である（ただし、凹部１２Ａ内面の傾斜角分布は上記の範囲内である）。

【００２４】また、凹部１２Ａの深さが３μｍを超えると、後工程で凹部１２Ａを平坦化する場合に凸部の頂上が平坦化膜（オーバーコート膜１４）で埋めきれず、所望の平坦性が得られなくなり、表示むらの原因となる。隣接する凹部１２Ａのピッチが２μｍ未満の場合、有機膜１１を形成するために用いる転写型の製作上の制約があり、加工時間が極めて長くなる、所望の反射特性が得られるだけの形状が形成できない、干渉光が発生する等の問題が生じる。また、実用上、前記転写型の製作に使用しうる５μｍ～１００μｍ径のダイヤモンド圧子を用いる場合、隣接する凹部１２Ａのピッチを２μｍ～５０μｍとすることが望ましい。

【００２５】有機膜（基材）１１は、第１の基板１０上に、スピンコート法などによりアクリル系レジストなどの感光性樹脂液を塗布した後、プリベークして感光性樹脂層を形成し、凹凸形状を有する凹凸面とその周縁の平坦面とからなる面を備える転写型を、上記感光性樹脂層の表面に押しつけて、上記転写型の凹凸面の形状を感光性樹脂層の表面に転写して得られたものである。金属反射膜１２には、Ａｌ、Ａｇなどの反射率の高い金属材料を用いることが好ましく、これらの金属材料をスパッタリング、真空蒸着などの成膜法により性膜することができる。金属反射膜１２の膜厚は、８ｎｍ～５０ｎｍ（８０Å～５００Å）の範囲であることが好ましい。これは、８ｎｍより膜厚が薄い場合には、金属反射膜１２による光の反射率が小さすぎるために反射モード時の表示が暗くなってしまうためであり、５０ｎｍより厚い場合には、金属反射膜１２の透光性が低下して透過モード時の表示が暗くなってしまうためである。

【００２６】また、金属反射膜１２の膜厚は、８ｎｍ～３０ｎｍ（８０Å～３００Å）の範囲であることがより好ましい。金属反射膜１２の膜厚をこのような範囲とす

るならば、透過モード時の表示を明るくすることができるので、透過モード時と反射モード時の表示の明るさの差を小さくすることができる。従って、前記２つの動作モードを切り替えながら使用する際の表示の見やすさを向上させることができる。さらに、金属反射膜１２の膜厚は８ｎｍ～２０ｎｍ（８０Å～２００Å）の範囲であることがもっとも好ましい。このような範囲の膜厚に設定することにより、反射モード時の明るさを保持してかつ透過モード時には格別に優れた明るさを実現することができる。

【００２７】電極層１５は、ＩＴＯ（Indium tin oxide）などの透明導電膜からなる短冊状の平面形状のものを多数整列形成したもので、外部の駆動回路（図示せず）に個々に接続されて液晶層３０を構成する液晶分子を駆動するために、オーバーコート膜１４に形成されている。同様に電極層２５もＩＴＯなどの透明導電膜からなる短冊状の平面形状のものを基板２０上に多数整列形成したものであり、個々に外部の駆動回路に接続されている。尚、電極層１５と電極層２５は互いに平面視直角に向くように配置されて上記の液晶表示装置１がパッシブマトリクス型とされている。

【００２８】本実施形態の半透過反射型液晶表示装置１では、上記の構成の複数の凹部１２Ａが形成された反射体７を備えたことにより、液晶セル３５に入射した入射光が反射体７で反射した反射光の反射率のピークが、法線方向P_1から３０度の範囲内まで至るように設定されており、反射モード時に、液晶表示装置１の表示面１ａに対する法線方向P_1から３０度の範囲内までの範囲の反射光量が多くなるので、反射光量は観察者の視点Ｏｂ１に近い方向の分布も高くなり、実用の視点において、特に、法線方向P_1と主たる観察方向α_1とのなす角度θ_1が０度乃至２０度において、明るい表示（画面）の液晶表示装置を実現できる。

【００２９】また、特に、液晶セル３５に入射した入射光が反射体７で反射した反射光の反射率のピークが、法線方向P_1から２０度の範囲内まで至るように設定されたものにあっては、反射モード時に、液晶表示装置１の表示面１ａに対する法線方向P_1から２０度の範囲内までの範囲の反射光量が多くなり、反射光量は観察者の視点Ob_1に近い方向の分布も高くなり、しかも反射光量が高い領域が広がるので、実用の視点において、特に、法線方向P_1と主たる観察方向α_1とのなす角度が０度乃至２０度において、明るい表示（画面）の液晶表示装置を実現できる。

【００３０】また、本実施形態の半透過反射型液晶表示装置１は、薄い膜厚の金属反射膜１２を用いているにもかかわらず、反射モード時に十分な明るさの表示を得ることができ、また、金属反射膜１２を薄くしているために透過モードにおいては格別に明るい表示が得られる。これは、有機膜１１の表面に先述の形状を形成していることによるものである。すなわち、金属反射膜１２を薄くして透光性を高めると、金属反射膜１２の反射率自体は低下するが、有機膜１１の表面に内面が球面の一部をなす多数の凹部１２Ａを連続して形成することにより、金属反射膜１２による光の反射効率を最大限に高めることで、反射モード時の表示の明るさを大きく損なうことなく、透過モード時の明るい表示を実現することができる。また、金属反射膜１２を８ｎｍ～２０ｎｍとするならば、本実施形態の液晶表示装置１は透過モードにおいて格別に明るい表示を実現することができる。これは、金属反射膜１２が極めて薄いことによる透光性の向上のみにより実現されるものではなく、上記の有機膜１１表面の形状による効果が加えられたことによるものである。すなわち、図２に示すように有機膜１１の表面に形成された凹部１２Ａの内面が球面であることにより、有機膜１１に基板１０側から入射する光に対してレンズ効果が作用し、有機膜１１を通過するバックライト５からの光が増強されることにより、格段に明るい表示を得ることができるものである。

【００３１】尚、上記実施形態では、本発明の液晶表示装置をパッシブマトリクス型の半透過反射型液晶表示装置に適用した場合について説明したが、本発明はこれに限定されるものではなく、アクティブマトリクス型の液晶表示装置にも適用可能である。その場合、例えば画素を構成する画素電極の上または下に先に記載の表面に光反射性を有する複数の凹部が形成された反射体を設ければよい。

【００３２】図３は、第１の実施形態の液晶表示装置１でバックライトを設けていないものの表示面１ａに、入射角３０°（表示面１ａに立てた垂線（法線）の一方の側から表示を観察する観察者の視点Ob_1の反対側から照明した外光の光軸とのなす角度）で外光を照射し、観察方向α（受光角）を垂線位置（法線位置）（０°）から６０°まで振ったときの受光角（°）と明るさ（反射率）との関係を示している。図３中、実線①、②は、第１の実施形態の液晶表示装置の受光角と反射率との関係を示しており、実線①と②のものの違いは、反射体７の凹部１２ａの深さ等が異なる点である。図３では、比較例として、従来から用いられている図１２または図１３に示した液晶表示装置でバックライトを設けていないタイプのものの受光角と反射率との関係を破線③で示した。

【００３３】図３から明らかなように、比較例の液晶表示装置では反射率のピークは正反射の角度（受光角３０°）にあり、受光角２０°より小さくなると反射率が大幅に小さくなっていることから、正反射方向から見た表示は明るく見えるものの他の方向から見た表示は暗く見えると考えられる。これに対して、実線①で示される特性を有する第１の実施形態の液晶表示装置１では、受光角３０°（正反射角度）を中心に特に反射率が高いピー

ク領域が存在し、しかもこの反射率のピークは法線方向（受光角０°）から２０度の範囲内まで延びている（言い換えれば反射率のピーク領域の一端は受光角０°から２０度の間に存在している。）ことから、受光角２０°～０°においては比較例に比べ高い反射率を示しており、法線方向に近い方向から表示を観察したとき、比較例のものより表示が明るく見えると考えられる。また、実線①で示される特性を有する第１の実施形態の液晶表示装置１では反射率のピークは受光角３０°の±約１０°の広い範囲に渡っている。また、実線②で示される特性を有する第１の実施形態の液晶表示装置１では、受光角３０°を中心に特に反射率が高いピーク領域が存在し、しかもこの反射率のピークは法線方向（受光角０°）から１０度の範囲内まで延びている（言い換えれば反射率のピーク領域の一端は受光角０°から１０度の間に存在している。）ことから、受光角１０°～０°においては比較例に比べ高い反射率を示しており、法線方向に近い方向から表示を観察したとき、比較例のものより表示が明るく見えると考えられる。また、実線②で示される特性を有する第１の実施形態の液晶表示装置１では反射率のピークは受光角３０°の±約２０°の広い範囲に渡っている。このため、本実施形態の液晶表示装置を携帯電話やノート型ＰＣなどの携帯電子機器の表示部に上記のいずれかの構成の本実施形態の液晶表示装置に組み込むと、特に視認性が良好なものとなる。

【００３４】（第２の実施形態）上記第１の実施形態においては、外部から入射した光を反射させる反射体７を基板１０と基板２０の間に内蔵した反射体内付けタイプの場合を説明したが、液晶層を挟持した２枚の基板の外側に反射体を設けた反射体外付けタイプとすることもできる。この構成を本発明の第２の実施形態とし、図４を参照して以下に説明する。尚、第１の実施形態と同一構成部分には、同一符号を付して説明を簡略化する。

【００３５】図４は、本発明の第２の実施形態である半透過反射型液晶表示装置２の部分断面構造を示す図である。第２の実施形態の半透過反射型液晶表示装置２が、第１の実施形態の半透過反射型液晶表示装置１と異なるところは、第１の基板１０と電極１５との間にオーバーコート膜１４とカラーフィルタ１３と反射体７が設けられておらず、第１の基板１０とバックライト５の間に第１の実施形態で説明したものと同様の反射体７が設けられている点である。第１の基板１０と第２の基板２０と、これら基板間に設けられた各構成部材により、液晶セル３５ａが構成されている。

【００３６】本実施形態の半透過反射型液晶表示装置２では、第１の実施形態と同様に該液晶表示装置２の表示面１ａに対する法線方向P_1と主たる観察方向α_1とのなす角度θ_1が０度乃至２０度のときに、液晶セル３５ａを通って入射した入射光が反射体７で反射した反射光の反射率のピークが、法線方向P_1から３０度の範囲内まで至るように設定されており、好ましくは、上記反射光の反射率のピークが、法線方向P_1から２０度の範囲内まで至るように設定されている。なお、上記第１の基板１０と電極１５との間に、図示されていないが、カラーフィルタ層を印刷などの方法により形成することによって、この液晶表示装置２をカラー表示できるようにしてもよい。

【００３７】本実施形態の半透過反射型液晶表示装置２では、上記の構成の複数の凹部１２Ａが形成された反射体７を備えたことにより、液晶セル３５ａを通って入射した入射光が反射体７で反射した反射光の反射率のピークが、法線方向P_1から３０度の範囲内まで至るように設定されており、反射モード時に、液晶表示装置２の表示面１ａに対する法線方向P_1から３０度の範囲内までの範囲の反射光量が多くなるので、反射光量は観察者の視点Ob_1に近い方向の分布も高くなり、実用の視点において、特に、法線方向P_1と主たる観察方向α_1とのなす角度θ_1が０度乃至２０度において、明るい表示（画面）の液晶表示装置を実現できる。

【００３８】また、特に、液晶セル３５ａを通って入射した入射光が反射体７で反射した反射光の反射率のピークが、法線方向P_1から２０度の範囲内まで至るように設定されたものにあっては、反射モード時に、液晶表示装置２の表示面１ａに対する法線方向P_1から２０度の範囲内までの範囲の反射光量が多くなり、反射光量は観察者の視点Ob_1に近い方向の分布も高くなり、しかも反射光量が高い領域が広がるので、実用の視点において、特に、法線方向P_1と主たる観察方向α_1とのなす角度が０度乃至２０度において、明るい表示（画面）の液晶表示装置を実現できる。また、この実施形態２で用いられた反射体７は、液晶セルを構成する基板の外側に配設可能なものであるため、透過型の液晶表示装置であれば問題なく装着して反射モード、透過モードいずれにおいても明るい表示が可能な半透過反射型液晶装置を形成することができる。尚、上記第２の実施の形態においては、本発明をパッシブマトリクス型の半透過反射型液晶表示装置に適用した例について説明したが、３端子型（ＴＦＴ：薄膜トランジスタ）アクティブマトリクス型や、２端子型アクティブマトリクス型の液晶表示装置についても、本発明は問題なく適用することができる。なお、上記第１～第２の実施形態においては、第１の基板１０の外側に偏光板１８が設けられた場合について説明したが、第１の基板１０の外側に偏光板１８が設けなくても良く、その場合には、液晶表示装置を構成する各部材の光学条件を良好な表示特性が得られるように調整される。また、上記第１～第２の実施形態においては、本発明の液晶表示装置を半透過反射型液晶表示装置に適用した場合について説明したが、反射型液晶表示装置にも適用でき、その場合にはバックライト５を設けなくてもよく、また、金属反射膜１２の厚みは５０ｎｍより厚く

てもよい。

【００３９】（第３の実施形態）図５は、本発明の第３の実施形態である反射型液晶表示装置の部分断面構造を模式的に示した図である。図５においてこの反射型液晶表示装置３は、液晶層３０を挟持して対向する透明なガラスなどからなる第１の基板（一方の基板）１０と、第２の基板（他方の基板）２０とをこれら２枚の基板１０、２０の周縁部に環状に設けられたシール材で接着一体化した構成である。第１の基板１０の液晶層３０側には順に、反射体４７と、透明介在層５３と、カラー表示を行うためのカラーフィルタ１３と、カラーフィルタ１３による凹凸を平坦化するためのオーバーコート膜（透明平坦化層）１４と、液晶層３０を駆動するための透明電極層１５と、液晶層３０を構成する液晶分子の配向を制御するための配向膜１６とが積層形成されている。また、第２の基板２０の液晶層３０側には順に、透明電極層２５、オーバーコート膜２４、配向膜２６が積層形成されている。

【００４０】上記の第１の基板１０と第２の基板２０と、これら基板間に設けられた各構成部材により、液晶セル３５ｂが構成されている。第１の基板１０の液晶層３０側と反対側（第１の基板１０の外面側）に、偏光板１８が設けられており、第２の基板２０の液晶層３０側と反対側（第２の基板２０の外面側）には、位相差板２７と、偏光板２８がこの順で積層されている。この偏光板２８の外側面は表示面１ａになっている。また、この反射型液晶表示装置３では、該液晶表示装置３の表示面１ａに対する法線方向P_1と主たる観察方向α_1とのなす角度θ_1が０度乃至２０度のときに、液晶セル３５ｂに入射した入射光が反射体４７で反射した反射光の反射率のピークが、法線方向P_1から３０度より小さい範囲内にあるように設定されており、好ましくは、上記反射光の反射率のピークが、法線方向P_1から２０度の範囲内にあるように設定されている。

【００４１】反射型液晶表示装置３に備えれた反射体４７は、図６に示すように例えばアルミニウムからなる平板状の基材６１の表面（基準面Ｈ）に多数の光反射性を有する凹部６３ａ、６３ｂ、６３ｃ、･･･（一般に凹部６３と称する）が互いに不規則に隣接して形成されている。

【００４２】これらの凹部６３は、斜視図を図７に、また断面図を図８に示すように、平面視円形の凹面を有し、この凹面は、図中Ｄで示す最深点が前記平面視円形の中心Ｏから一方向（Ｙ方向）にずれたスプーン形の非球面をなし、１側部Ａで傾斜角（曲面上の任意の点における接平面Ｐと基材表面Ｈとのなす角度の絶対値）δが最大、すなわち最大傾斜角δmaxとなるように形成されている。従って凹面中で、側部Ａとは中心Ｏを挟んで反対側となる側部Ｂにおける傾斜角δbは、側部Ａの傾斜角（最大傾斜角δmax）より小さくなっている。本実施形態で備えられた反射体４７において、凹部６３ａ、６３ｂ、６３ｃ･･･におけるそれぞれの最大傾斜角δmaxは、２°～９０°の範囲内で不規則にばらついている。しかし多くの凹部は最大傾斜角δmaxが４°～３５°の範囲内で不規則にばらついている。

【００４３】またこの凹部６３は、その凹面が単一の極小点（傾斜角がゼロとなる曲面上の点）Ｄを有している。そしてこの極小点Ｄと基材の基準面Ｈとの距離が凹部６３の深さｄを形成し、この深さｄは、凹部６３ａ、６３ｂ、６３ｃ、…についてそれぞれ０．１μm～３μmの範囲内で不規則にばらついている。また、凹部６３ａ、６３ｂ、６３ｃは、隣接する凹部のピッチが２μm～５０μmの範囲内で不規則に配置されている。

【００４４】本実施形態において、前記の各凹部６３ａ、６３ｂ、６３ｃ、…は、図９に示すように、それぞれの凹面の最大傾斜角δmaxを有する側部Ａが、観察者の視点Ｏb_1から遠い方向Ｙの方向に揃うように形成されている。一般に外光は様々な方向から凹部６３に入射し、凹部６３の曲面上で入射点の傾斜角に応じて様々な方向に反射するので、反射光は全体として広い視野角の範囲に拡散するが、図１０に示すように、例えばＯａ方向から入射する外光に注目してその反射の方向を追跡すると、反射光は最大傾斜角δmaxを有する側部Ａとは反対の方向、すなわち観察者側の、図１０に示すＷの範囲（明視範囲）に、より多くの光が偏って集まる傾向がある。従ってこの明視範囲Ｗの範囲内に観察者の視点Ｏｂ1を置くようにすれば、他の方向から観察する場合に比べ、より明るく見えるようになる。言い換えれば、観察者の視点Ｏb_1は通常表示面１ａの法線方向P_1に近い方向、より具体的には法線方向P_1から２０度までの範囲内の方向に集中するので、この範囲に、より多くの光が集まるように設定（設計）しておけば、液晶表示装置の表示面１ａに対する法線方向P_1に近い方向から観察すると、他の方向から観察する場合に比べ、より明るく見えるようになる。この明視範囲Ｗの広がりおよび方向は、凹部６３の形状と配列方向を調整することにより制御することができる。

【００４５】本実施形態の反射体４７では、各凹部６３が単一の極小点を有する非球面に形成されているので、光の反射角の変化が滑らかで、特定の視角において反射光が眩しいほどに強く見えることはない。各凹部６３ａ、６３ｂ、６３ｃ、…の最大傾斜角δmaxは２°～９０°の範囲内とされているが、中でも４°～３５°の範囲内とされているものが多い。従って凹部６３の全面に入射した光は反射光が無駄にならならない範囲で広範囲に散乱し視界が全体として明るいが、中でも特定の視野角内（法線方向P_1から３０度より小さい範囲内の方向、特に、法線方向P_1から２０度までの範囲内の方向）に多くの光が偏って反射され、この視野角内で観察するとき（実用の視点において、特に、前記法線方向と

主たる観察方向とのなす角度が０度乃至２０度において観察するとき）特に明るく見える。凹部６３の深さは、０．１μｍ～３μｍの範囲内で不規則に形成されかつ各凹部６３が不規則に隣接して配置されているので、反射型液晶表示装置に組み込んだときモアレ模様が発生せず、また特定視角における反射光量のピーク的な集中が緩和され、視界内の反射光量の変化がなだらかになっている。

【００４６】上記の反射体４７は、図９に示すように各凹部６３ａ、６３ｂ、６３ｃ、…の最大傾斜角を有する側部Ａの方向が観察者の視点Ｏｂ$_1$から遠い側（Ｙ方向）となるように装着されている。また、液晶層３０を挟む透明電極層１５と透明電極層２５とは、互いに直交するストライプ状に形成されていてその交点領域が画素となる単純マトリックス型の液晶装置を構成している。

【００４７】本実施形態の反射型液晶表示装置３では、表示面１ａに外光が入射すると、入射光は液晶パネル３５ｂ内に入って各層を透過して反射体４７の表面に到達し、反射体４７の凹部６３ａ、６３ｂ、６３ｃ、…の曲面によって広角度に反射し、再び前記各層を透過して表示面１ａから出射する。この出射光は広い視野角範囲に散乱するので、この表示面１ａは広い視角から光源の映り込みなく観察することができるが、配向方向Ｙとは反対側の視点Ｏｂ$_1$方向から観察するとき、特に、前記法線方向Ｐ$_1$と主たる観察方向α$_1$とのなす角度が０度乃至２０度で観察するとき、画面の明るさが最大となる。

【００４８】本実施形態の反射型液晶表示装置３では、上記の構成の複数の凹部６３が形成された反射体４７を備えたことにより、液晶セル３５ｂに入射した入射光が反射体４７で反射した反射光の反射率のピークが、法線方向Ｐ$_1$から３０度より小さい範囲内にあるように設定されており、反射モード時に、液晶表示装置３の表示面１ａに対する法線方向Ｐ$_1$から３０度より小さい範囲内の反射光量が多くなるので、反射光量は観察者の視点Ｏｂ$_1$に近い方向の分布も高くなり、実用の視点において、特に、法線方向Ｐ$_1$と主たる観察方向α$_1$とのなす角度θ$_1$が０度乃至２０度において、明るい表示（画面）の液晶表示装置を実現できる。

【００４９】また、特に、液晶セル３５ｂに入射した入射光が反射体４７で反射した反射光の反射率のピークが、法線方向Ｐ$_1$から２０度の範囲内にあるように設定されたものにあっては、反射モード時に、液晶表示装置３の表示面１ａに対する法線方向Ｐ$_1$から２０度の範囲内の反射光量が多くなり、反射光量は観察者の視点Ｏｂ$_1$に近い方向の分布も高くなり、しかも反射光量が高い領域が広がるので、実用の視点において、特に、法線方向Ｐ$_1$と主たる観察方向α$_1$とのなす角度が０度乃至２０度）において、明るい表示（画面）の液晶表示装置を実現できる。

【００５０】なお、図５に示した第３の実施形態の反射型液晶表示装置３においては、反射体４７を電極層１５とは別の層として形成したが、電極層１５自体を反射体４７により形成し、かつ電極層１５を図５の反射体４７の位置に形成すれば、透明電極層が反射体を兼ねることができて、反射型液晶表示装置の層構成が単純化される。また、第３の実施形態においては、外部から入射した光を反射させる反射体４７を基板１０と基板２０の間に内蔵した反射体内付けタイプの場合を説明したが、液晶層を挟持した２枚の基板の外側に反射体を設けた反射体外付けタイプとすることもできる。また、第３の実施形態においては、本発明の液晶表示装置を反射型液晶表示装置に適用した場合について説明したが、半透過反射型液晶表示装置にも適用でき、その場合には反射体４７の厚みを８ｎｍ～５０ｎｍ（８０Å～５００Å）の範囲、好ましくは８ｎｍ～３０ｎｍ（８０Å～３００Å）の範囲、さらに好ましくは８ｎｍ～２０ｎｍ（８０Å～２００Å）の範囲にし、第１の基板１０の外面側にバックライトを備えるようにすればよい。

【００５１】第３の実施形態では、本発明を単純マトリックス型の反射型液晶表示装置に適用した場合について説明したが、薄膜トランジスタまたは薄膜ダイオードを用いたアクティブマトリックス型、またはセグメント型の液晶表示装置などにも同様に適用が可能である。これらの液晶表示装置はいずれも本発明に含まれるものである。なお、第１～第３の実施形態においては、第２の基板２０と偏光板２８との間に位相差板が１枚設けられた場合について説明したが、位相差板は複数設けられていてもよい。

【００５２】図１１は、第３の実施形態の反射型液晶表示装置３の表示面１ａに、入射角３０°（表示面１ａに立てた垂線（法線）の一方の側から表示を観察する観察者の視点Ｏｂ$_1$ の反対側から照明した外光の光軸とのなす角度）で外光を照射し、観察方向α（受光角）を垂線位置（法線位置）（０°）から６０°まで振ったときの受光角（°）と明るさ（反射率）との関係を示している。図１１中、実線④、⑤、一点鎖線⑥は、第３の実施形態の反射型液晶表示装置の受光角と反射率との関係を示しており、実線④と⑤と一点鎖線⑥のものの違いは、反射体４７の凹部６３の形状や配列方向等が異なる点である。図１１では、比較例として、従来から用いられている図１２または図１３に示した液晶表示装置でバックライトを設けていないタイプのものの受光角と反射率との関係を破線③で示した。

【００５３】図１１から明らかなように、比較例の液晶表示装置では反射率のピークは正反射の角度（受光角３０°）にあり、受光角２０°より小さくなると反射率が大幅に小さくなっていることから、正反射方向から見た表示は明るく見えるものの他の方向から見た表示は暗く見えると考えられる。これに対して、実線④で示される特性を有する第３の実施形態の液晶表示装置３では反射

率のピークが法線方向（受光角０°）から３０度より小さい範囲内にあり、受光角約２５°を中心に特に反射率が高いピーク領域が存在しており、受光角０°～３０°においては比較例に比べ高い反射率を示しており、法線方向に近い方向から表示を観察したとき、比較例のものより表示が明るく見えると考えられる。また、実線⑤で示される特性を有する第３の実施形態の液晶表示装置３では反射率のピークが法線方向（受光角０°）から２０度の範囲内にあり、受光角約１５°を中心に特に反射率が高いピーク領域が存在しており、受光角０°～２２°においては比較例に比べ高い反射率を示しており、法線方向に近い方向から表示を観察したとき、比較例のものより表示が明るく見えると考えられる。また、一点鎖線⑥で示される特性を有する第３の実施形態の液晶表示装置３では反射率のピークが法線方向（受光角０°）から約２０度の範囲内にあり、受光角約２０°付近の反射率は、正反射の角度の反射率より高くなっており、受光角０°～２５°においては比較例に比べ高い反射率を示しており、法線方向に近い方向から表示を観察したとき、比較例のものより表示が明るく見えると考えられる。また、実線④又は⑤又は一点鎖線⑥で示される特性を有する第３の実施形態の液晶表示装置３においては、入射光の正反射角度に対して非対称の反射率分布となる反射特性を備えており、しかも反射率の最大値は入射光の正反射角度（本実施形態では受光角３０°）より小さい反射角度範囲（受光角度範囲）にある反射特性を備えており、また、特に、一点鎖線⑥で示される特性を有する第３の実施形態の液晶表示装置３では反射率分布を示すグラフのプロファイルが階段状であり、反射率の最大値は受光角２０°付近にあり、該最大値は上記階段状のプロファイルの頂部に存在しているが、比較例のものでは入射光の正反射角度に対して対称の反射率分布となる反射特性を備えている。このため、本実施形態の液晶表示装置を携帯電話やノート型ＰＣなどの携帯電子機器の表示部に上記のいずれかの構成の本実施形態の液晶表示装置に組み込むと、特に視認性が良好なものとなる。

【００５４】（第４の実施形態）図１５は、本発明の第４の実施形態である反射型液晶表示装置の部分断面構造を模式的に示した図である。図１５の反射型液晶表示装置４が図５に示した反射型液晶表示装置３と異なるところは、液晶セル３５ｂ内に設けられる反射体の構成が異なる点である。本実施形態の反射型液晶表示装置４に備えられた反射体４７は、例えばアルミニウムからなる平板状の基材６１の表面（基準面）に多数の光反射性を有する凹部１６３ａ、１６３ｂ、１６３ｃ、…（一般に凹部１６３と称する）が互いに不規則に隣接して形成されている。

【００５５】これらの凹部１６３は、断面図を図１６に示すように、凹部１６３の特定縦断面Ｙにおける内面形状は、凹部の一の周辺部Ｓ１から最深点Ｄに至る第１曲線Ｊと、この第１曲線Ｊに連続して、凹部の最深点Ｄから第３曲線又は直線Ｌに至る第２曲線Ｋと、この第２曲線Ｋに連続して、他の周辺部Ｓ２に至る第３曲線又は直線Ｌとからなっている。これら第１と第２の曲線は、最深点Ｄにおいて共に基材表面Ｓに対する傾斜角がゼロとなり、互いにつながっている。

【００５６】第１曲線Ｊの基材表面Ｓに対する傾斜角は第２曲線Ｋの傾斜角や第３曲線又は直線Ｌよりも急であって、最深点Ｄは凹部３の中心ＯからＹ方向にずれた位置にある。すなわち、第１曲線Ｊの基材表面Ｓに対する傾斜角の絶対値の平均値（以下、第１曲線Ｊの傾斜角の平均値という。）は、第２曲線Ｋの基材表面Ｓに対する傾斜角の絶対値の平均値や、第３曲線又は直線Ｌの基材表面Ｓに対する傾斜角の絶対値の平均値より大きくされている。また、第２曲線Ｋの基材表面Ｓに対する傾斜角の絶対値の平均値（以下、第２曲線Ｋの傾斜角の平均値という。）と第３の曲線又は直線Ｌの基材表面Ｓに対する傾斜角の絶対値の平均値（以下、第３曲線又は直線Ｌの傾斜角の平均値）とは異なっており、本実施形態では第３の曲線又は直線Ｌの傾斜角の平均値の方が第２曲線Ｋの傾斜角の平均値よりも大きくされている。

【００５７】言い換えれば、第１曲線Ｊの曲率半径R_1の大きさは、第２曲線Ｋの曲率半径R_2や第３曲線又は直線Ｌの曲率半径R_3より小さくされており、第３曲線又は直線Ｌの曲率半径R_3の大きさは第２曲線Ｋの曲率半径R_2より小さくされている。なお、上記第３曲線又は直線Ｌは曲率半径R_3が∞である場合に、直線となる。

【００５８】凹部１６３ａ、１６３ｂ、１６３ｃ、…における第１曲線Ｊの基材表面Ｓに対する傾斜角の平均値は１°～８９°の範囲で不規則にばらついている。また、凹部１６３ａ、１６３ｂ、１６３ｃ、…における第２曲線Ｋの基材表面Ｓに対する傾斜角の平均値は０．５°～８８°の範囲で不規則にばらついている。また、凹部１６３ａ、１６３ｂ、１６３ｃ、…における第３曲線又は直線Ｌの基材表面Ｓに対する傾斜角の平均値は０．５°～８８°の範囲で不規則にばらついている。

【００５９】第１曲線と第２曲線と第３曲線又は直線の傾斜角は、いずれもなだらかに変化しているので、第１曲線Ｊの最大傾斜角δmax（絶対値）は、第２曲線Ｋの最大傾斜角（絶対値）δｂや第３曲線又は直線Ｌの最大傾斜角（絶対値）δｃよりも大きくなっている。また、第１曲線Ｊと第２曲線Ｋとが接する最深点Ｄの基材表面に対する傾斜角はゼロとなっており、傾斜角が負の値である第１曲線Ｊと傾斜角が正の値である第２曲線Ｋとは、なだらかに連続しており、傾斜角が正の値である第２曲線Ｋと第３曲線又は直線Ｌとは、なだらかに連続している。本実施形態の反射体において、凹部１６３ａ、１６３ｂ、１６３ｃ、…におけるそれぞれの最大傾斜角δmaxは、２～９０°の範囲内で不規則にばらついてい

る。しかし多くの凹部は最大傾斜角δmaxが4°～35°の範囲内で不規則にばらついている。

【0060】またこの凹部163は、その凹面が単一の極小点（傾斜角がゼロとなる曲面上の点）Dを有している。そしてこの極小点Dと基材の基材表面Sとの距離が凹部163の深さdを形成し、この深さdは、凹部163a、163b、163c、…についてそれぞれ0.1μm～3μmの範囲内で不規則にばらついている。また、凹部163a、163b、163cは、隣接する凹部のピッチが5μm～50μmの範囲内で不規則に配置されている。

【0061】本実施形態においては、凹部163a、163b、163c、…における各特定縦断面Yは、いずれも同じ方向になっている。また、各々の第1曲線Jが観察者の視点Ob_1から遠い方向Yの方向に揃うように形成されている。また、各々の第2曲線K、第3曲線又直線Lが観察者の視点Ob_1から遠い方向Yの方向と反対方向に揃うように形成されている。

【0062】本実施形態の反射体147では、各々の第1曲線Jが単一の方向に配向するように形成されており、しかも第1曲線Jの傾斜角の平均値は、第2曲線Kの基材表面Sに対する傾斜角の平均値や、第3曲線又は直線Lの基材表面Sに対する傾斜角の平均値より大きくされいるため、その反射特性は、基材表面Sに対する正反射の方向からずれたものとなっている。すなわち、Y方向の斜め上方からの入射光に対する反射光は、正反射の方向よりも、基材表面Sに対する法線方向にシフトした方向に明るい表示範囲がシフトしたものとなっている。さらに、本実施形態の反射体147では、各々第2曲線K、第3曲線又は直線Lが第1曲線Jと反対方向に配向するように形成されており、さらに第3の曲線又は直線Lの傾斜角の平均値の方が第2曲線Kの傾斜角の平均値よりも大きくされているので、特定縦断面Yにおける総合的な反射特性としては、第2曲線K周辺の面によって反射される方向の反射率が増加し、さらにこの反射率の大きさよりも第3曲線又は直線L周辺の面によって反射される方向の反射率が大きくなったものとなる。したがって、特定の方向に反射光を適度に集中させた反射特性とすることができる。

【0063】図17は、第4の実施形態の反射型液晶表示装置4の表示面1aに、入射角30°（表示面1aに立てた垂線（法線）の一方の側から表示を観察する観察者の視点Ob_1の反対側から照明した外光の光軸とのなす角度）で外光を照射し、観察方向α（受光角）を垂線位置（法線位置）（0°）から60°まで振ったときの受光角（°）と明るさ（反射率）との関係を示している。図17中、一点鎖線⑦は、第4の実施形態の反射型液晶表示装置の受光角と反射率との関係を示している。図17では、比較例として、従来から用いられている図12または図13に示した液晶表示装置でバックライトを設けていないタイプのものの受光角と反射率との関係を破線③で示し、この比較例の液晶表示装置の反射特性は図3や図11を用いて説明した通りであるので説明を略す。

【0064】一点鎖線⑦で示される特性を有する第4の実施形態の液晶表示装置4では反射率分布を示すグラフのプロファイルが階段状であり、しかも入射光の正反射角度に対して非対称となる反射特性を備えており、また、反射率の最大値は入射光の正反射角度（本実施形態では受光角30°）より小さい反射角度範囲（受光角度範囲）にある受光角20°付近に存在し、反射率の最大値は上記階段状のプロファイルの頂部に存在する反射特性を備えており、しかも反射率の最大値は第3の実施形態の液晶表示装置よりも大きな値が得られる。また、この第4の実施形態の液晶表示装置4では、受光角約20°付近の反射率は、正反射の角度の反射率より高くなっており、受光角0°～25°においては比較例に比べ高い反射率を示しており、法線方向に近い方向から表示を観察したとき、比較例のものより表示が明るく見えると考えられる。

【0065】（第5の実施形態）次に、本発明の第5の実施形態である反射型液晶表示装置について説明する。第5の実施形態の反射型液晶表示装置が図15に示した第4の実施形態の反射型液晶表示装置4と異なるところは、液晶セル内に設けられる反射体の構成が異なる点である。本実施の形態の反射型液晶表示装置に備えられた反射体が第4の実施形態の反射型液晶表示装置に備えられた反射体と異なるところは、平板状の基材61の表面（基準面）に形成された凹部の形状が異なるところである。図18は本実施の形態の反射型液晶表示装置に備えられた反射体247の凹部263の説明図であり、図18（a）は、凹部263の断面図、図18（b）は凹部263の平面図である。

【0066】図18に示すように、各凹部263の内面は、周縁曲面264aと、周縁曲面264aに囲まれた位置ににある底曲面4bとから形成されている。周縁曲面264aは、中心をO_1として半径がR_4である球面の一部である。また、底曲面264bは、中心をO_2として半径がR_5である球面の一部である。各々の球面の中心であるO_1とO_2とから、反射体の表面に立てた法線は、各々別個の直線L_1、L_2上に位置する。また、凹部263…における各特定縦断面Yはいずれも同じ方向になっている。また、各々の底曲面264bが観察者の視点Ob_1から近い方向（観察者の視点Ob_1から遠い方向Yの方向と反対方向、即ち図18の左側方向）に揃うように形成されている。図18の右側の方向が光の入射側である。

【0067】各々の半径R_1とR_2とは、$R_1 < R_2$の関係にあり、かつ$5\mu m \leqq R_1 \leqq 70\mu m$、$10\mu m \leqq R_2 \leqq 100\mu m$の範囲で変化するものである。また、図2

（ａ）において、θ_4は周縁曲面２６４ａの傾斜角で、４°≦θ_4≦３５°および－３５°≦θ_4≦－４°の範囲で変化するものである。また、θ_5は底曲面２６４ｂの傾斜角で、－１７°≦θ_5≦１７°の範囲で変化するものである。なお、平面方向から見た周縁曲面２６４ａの半径r_4及び底曲面２６４ｂの半径r_5は、各々の半径、R_4，R_5及び傾斜角θ_4、θ_5に応じて決まるものである。

【００６８】凹部２６３の深さｄは０．１ないし３μｍの範囲で各凹部毎にランダムな値をとる。凹部２６３の深さが０．１μｍに満たないと、正反射が強くなり過ぎるからである。隣接する凹部２６３のピッチは２μｍないし５０μｍの範囲でランダムに配置する。なぜなら、仮に隣接する凹部２６３のピッチに規則性があると、光の干渉色が出て反射光が色付いてしまうという不具合があるからである。また、隣接する凹部２６３のピッチが２μｍ未満の場合、反射体の凹部を製作上の制約があり、加工時間が極めて長くなる。

【００６９】第５の実施形態の反射型液晶表示装置の受光角と反射率との関係を上記第３の実施形態で行った方法と同様にして測定した結果、第５の実施形態の反射型液晶表示装置の受光角と反射率との関係は図１１の一点鎖線⑥で示される特性と同様の特性を備えている。このように、反射体２４７が備えられた本実施形態の反射型液晶表示装置においては、凹部２６３の内面に、半径の小さい球面の一部からなる周縁曲面２６４ａが存在し、比較的絶対値の大きい傾斜角の範囲を与えるので、受光角約１５°～４５°という広い反射角度範囲で良好な反射率を有している。また、半径の大きい球面の一部からなる底曲面２６４ｂ、すなわち平坦面に近い曲面が偏在するので、特定の範囲の傾斜角を与える内面の割合が高くなる。その結果、正反射角度（本実施形態では受光角３０度）よりも小さい反射角度における反射率が最も高くなり、その方向をピークとして近傍の反射率も高くなっている。なお、図１８の左側の方向から入射した場合には、入射角度である３０度と対象な方向の反射角度３０度よりも、大きい反射角度における反射率が最も高くなり、その方向をピークとして近傍の反射率も高くなる。

【００７０】

【発明の効果】以上、詳細に説明したように、本発明の液晶表示装置によれば、液晶表示装置の表示面に対する法線方向と主たる観察方向とのなす角度が０度乃至２０度のときに、前記液晶表示装置に入射した入射光が前記反射体で反射した反射光の反射率のピークが、前記法線方向から３０度の範囲内まで至るように設定されたことにより、好ましくは、前記液晶表示装置に入射した入射光が前記反射体で反射した反射光の反射率のピークが、前記法線方向から２０度の範囲内まで至るように設定されたことにより、液晶表示装置の表示面に対する法線方向に近い方向から表示を観察したとき、他の視角より明るく見えるような視角特性を有することができる。また、本発明の液晶表示装置によれば、液晶表示装置の表示面に対する法線方向と主たる観察方向とのなす角度が０度乃至２０度のときに、前記液晶表示装置に入射した入射光が前記反射体で反射した反射光の反射率のピークが、前記法線方向から３０度より小さい範囲にあるように設定されたことにより、好ましくは、前記液晶表示装置に入射した入射光が前記反射体で反射した反射光の反射率のピークが、前記法線方向から２０度の範囲にあるように設定されたことにより、液晶表示装置の表示面に対する法線方向に近い方向から表示を観察したとき、他の視角より明るく見えるような視角特性を有することができる。また、本発明の携帯電子機器によれば、上記のいずれかの構成の本発明の液晶表示装置が表示部に備えられたことにより、反射モードの動作、あるいは反射モードと透過モードのいずれの動作においても表示面（画面）の視認性に優れた携帯電話やノート型ＰＣ等の携帯電子機器が得られる。

【図面の簡単な説明】

【図１】　本発明の第１の実施形態の半透過反射型液晶表示装置の部分断面構造を示す図。

【図２】　図１の液晶表示装置に備えられた有機膜と金属反射膜とからなる反射体を拡大して示した斜視図。

【図３】　第１の実施形態の液晶表示装置と比較例の液晶表示装置の受光角と反射率との関係を示すグラフ。

【図４】　本発明の第２の実施形態の半透過反射型液晶表示装置の部分断面構造を示す図。

【図５】　本発明の第３の実施形態の反射型液晶表示装置の部分断面構造を示す図。

【図６】　図５の液晶表示装置に備えられた反射体を拡大して示した斜視図。

【図７】　図６の反射体の表面に形成されたの一凹部を示す斜視図。

【図８】　図７の凹部を示す断面図。

【図９】　図６の反射体の部分を示す断面図。

【図１０】図６の反射体の一凹部を示す断面図。

【図１１】　第３の実施形態の液晶表示装置と比較例の液晶表示装置の受光角と反射率との関係を示すグラフ。

【図１２】　従来の半透過反射型液晶表示装置の概略構成を示す断面図。

【図１３】従来の半透過反射型液晶表示装置のその他の例を示す断面図。

【図１４】　携帯電話に備えられた半透過反射型液晶表示装置の使用状態の説明図。

【図１５】　本発明の第４の実施形態の反射型液晶表示装置の部分断面構造を示す図。

【図１６】　図１５の反射型液晶表示装置に備えられた反射体の表面に形成された凹部を示す断面図。

【図１７】　第４の実施形態の液晶表示装置と比較例の

液晶表示装置の受光角と反射率との関係を示すグラフ。

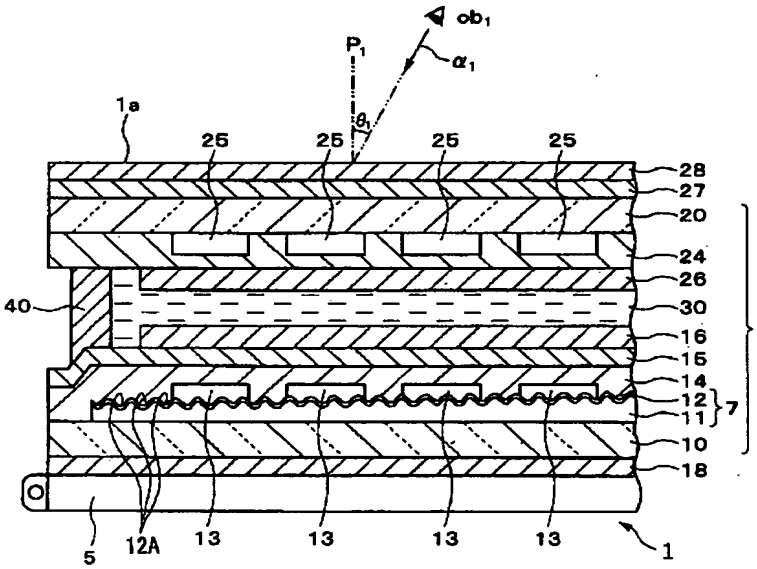
【図１８】　本発明の第５の本実施形態の反射型液晶表示装置に備えられた反射体の凹部の説明図。

【符号の説明】

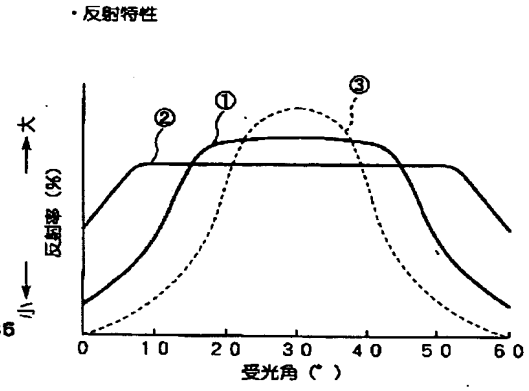
１、２、３、４　液晶表示装置
１ａ　表示面
５　バックライト
７、４７、１４７、２４７　反射体
１０　基板（一方の基板）
１１　有機膜（基材）
１２　金属反射膜（金属膜）
１２Ａ、６３、６３ａ、６３ｂ、６３ｃ、１６３、２６３　凹部
１３　カラーフィルタ
１４、２４　オーバーコート膜
１５、２５　透明電極層（電極）

１６、２６　配向膜
１８、２８　偏光板
２０　基板（他方の基板）
２７　位相差板
３０　液晶層
３５、３５ａ、３５ｂ　液晶セル
４０　シール材
５３　透明介在層
６１　基材
２６４ａ　周縁曲面
２６４ｂ　底曲面
P_1　法線方向
Ob_1　視点
θ_1　角度
α_1　観察方向

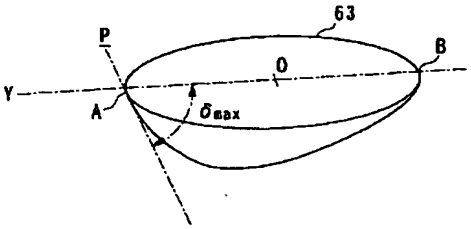
【図１】



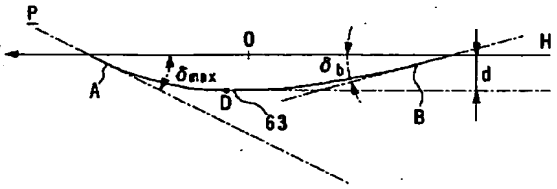
【図３】



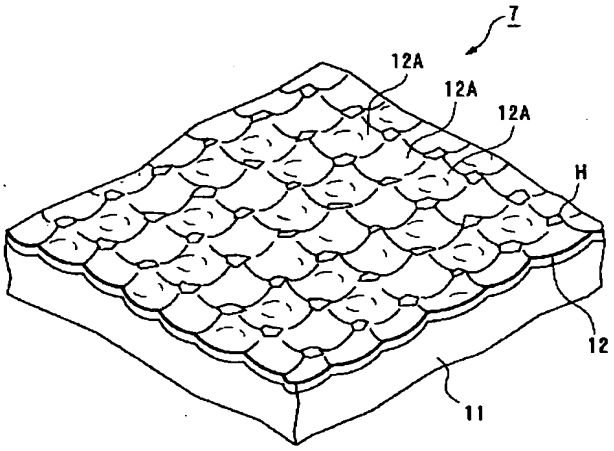
【図７】



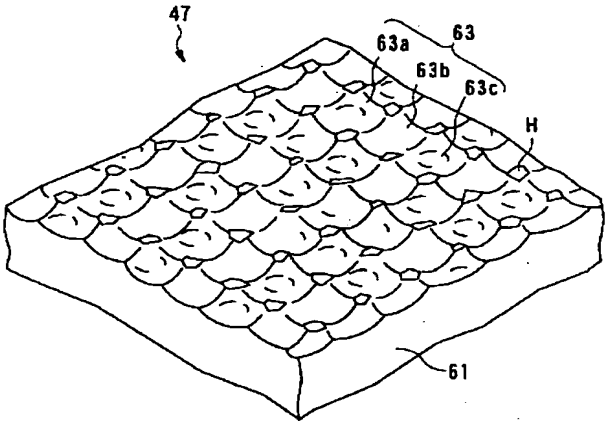
【図８】



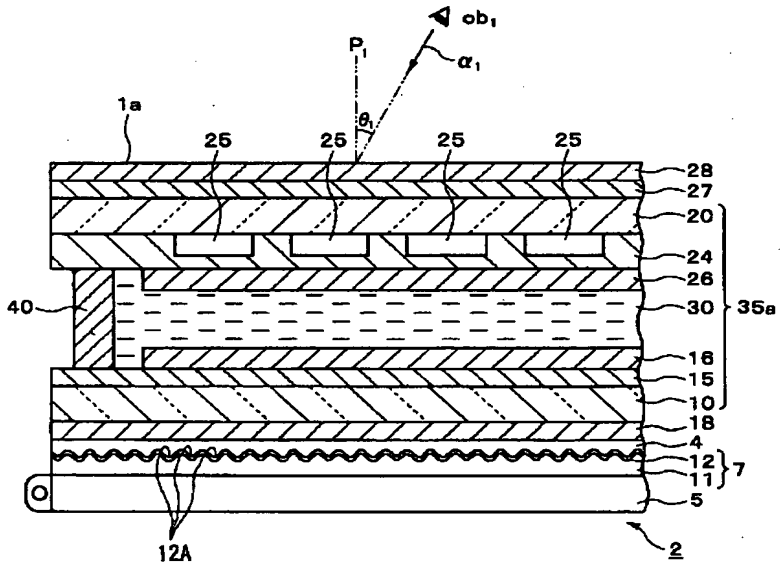
【図２】



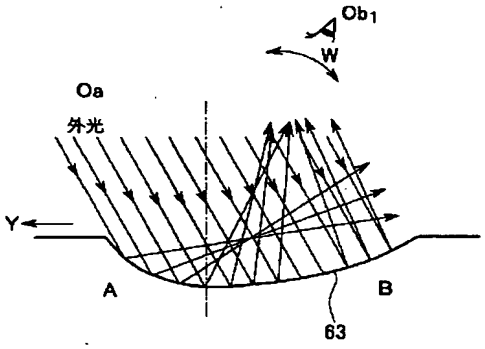
【図６】



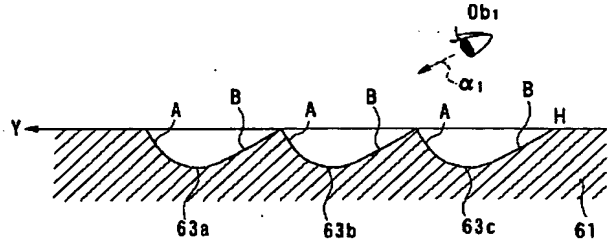
【図４】



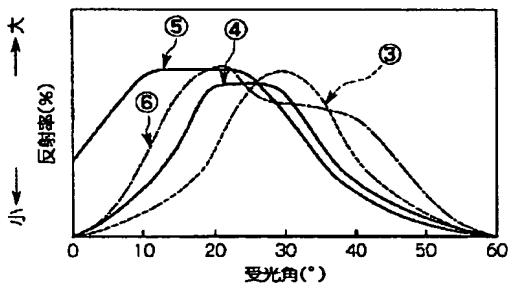
【図１０】



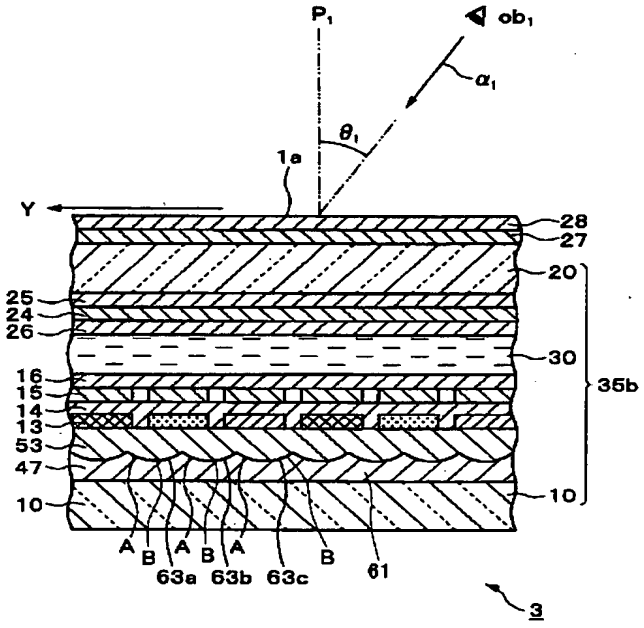
【図９】



【図１１】



【図５】



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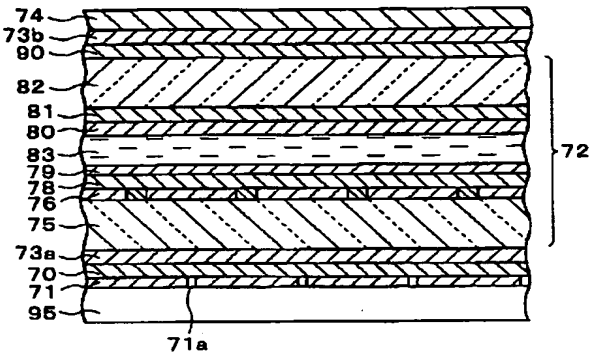

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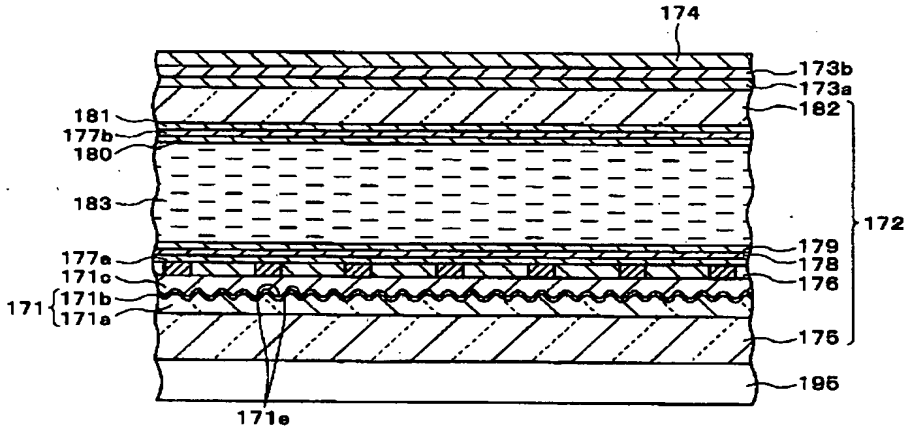

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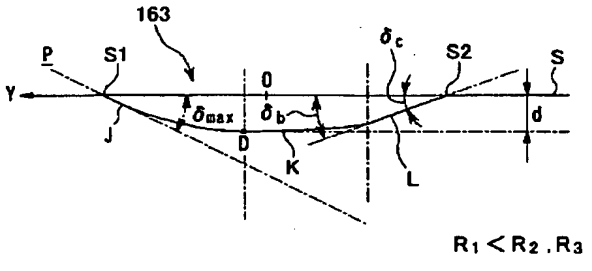

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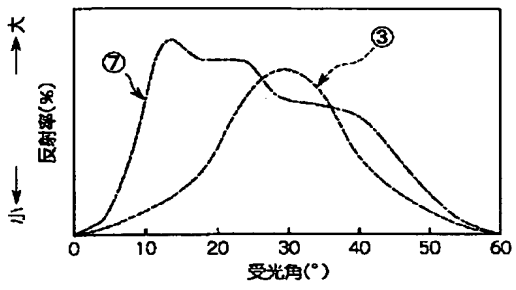

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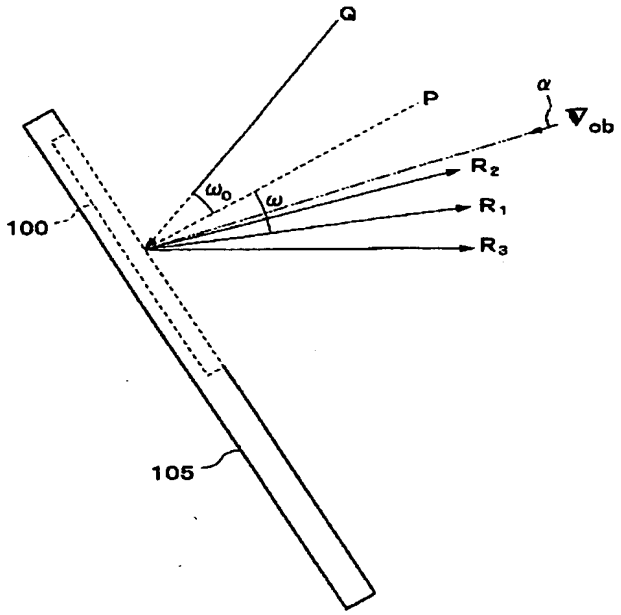

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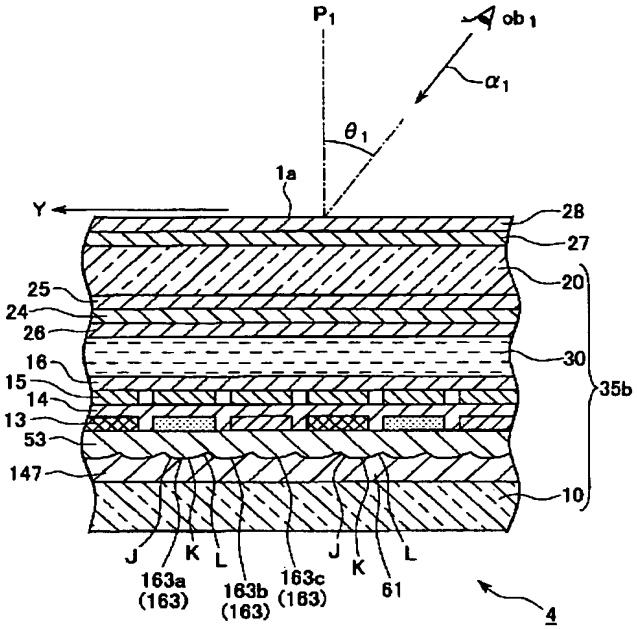
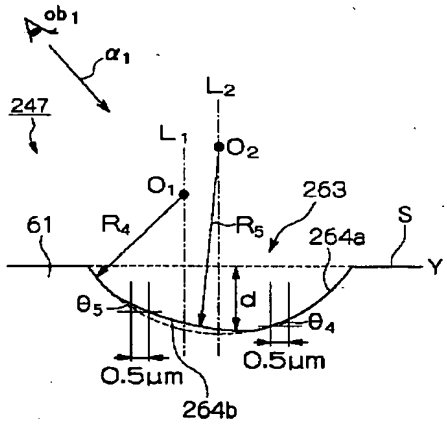


【図１８】

(a)



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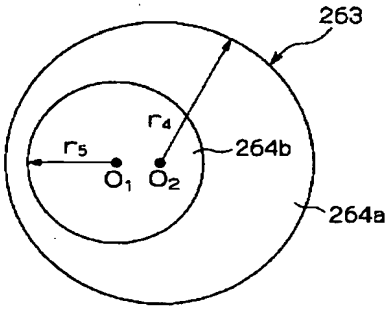

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